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A PROPOSED DOCTRINE FOR FIELD ARMY COMMUNICATIONS CONTROL

A thesis presented to the Faculty of the U. S. Army
Command and General Staff College in partial
fulfillment of the requirements of the
degree

MASTER OF MILITARY ART AND SCIENCE

by
CLARE R. J. ROGERS, MAJ, USA

Fort Leavenworth, Kansas
1967

U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE

(Abstract Approval Page)

Name of Candidate Clare Roy John Rogers, Major, Signal Corps, U.S.A.

Title of Thesis A Proposed Doctrine for Field Army Communications Systems Control.

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Charles J. Norris, Research and Thesis Monitor

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Date 22 May 1967

The opinions and conclusions expressed herein are those of the individual student author and do not necessarily represent the views of either the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

A commander without communications is only as effective as the range of his voice. Control of the diversified and widely-scattered elements of the modern army demands swift, reliable, and secure communications to make the commander in fact what he is in name. In the years since World War II the problem of controlling signal operations has grown more and more complicated with the introduction of new, complex, and ever-changing machines and equipment. This thesis examines one area of signal operations: the technical problem of day-to-day control of the electrical and electronic communications systems of the field army.

The nature and extent of this problem is formulated by analyzing the development of tactical communications systems, their technical characteristics, and the requirements which they must satisfy within the framework of the future field army. The field army network is composed of signal centers providing support to using organizations by establishing communications facilities at major headquarters or within designated geographical areas. These signal centers are linked by multichannel systems operating over cable, radio relay, or tropospheric scatter radio transmission media. Each system is capable of providing several voice channels with a bandwidth of 4 kc and a circuit net loss

of 3 db. The thousands of circuits required to support the subordinate units of the field army are obtained by interconnecting channels from one signal center to another until a path between the desired locations is established.

The present U.S. Army doctrine and the various methods which have been developed over the years for controlling communications networks are reviewed and the following criteria which an effective tactical communications systems control doctrine must meet are established.

1. The doctrine must be compatible with the organization and capabilities of the field army signal brigade, the senior signal headquarters within the field army.

2. It must provide a control element with sufficient authority to direct changes in the field army communications network and insure that these changes are made rapidly and effectively. The control element must be equipped to transmit its instructions rapidly to the executing signal agencies.

3. Centralized control of the field army communications network must be maintained, while insuring that systems control actions are executed at the lowest possible level.

4. Communications operators and users must be simply identified in terms of their functions and their requirements.

5. A simple and concise method for identifying systems and circuits must be provided.

6. A system of communications records, reports, and orders which can be prepared and updated rapidly and efficiently by either manual or automated procedures must be established.

Field Manual FM 11-21, Tactical Signal Communication Systems, Army, Corps, and Division, contains the present U.S. Army doctrine for systems control. It is found to be general in nature and not compatible with the signal organization of the 1965-1970 field army. The guidance of FM 11-21 does not appear capable of application to automated systems control operations due to its lack of specific direction in the matter of systems control orders and reports. U.S. Seventh Army has developed a systems control doctrine differing completely from FM 11-21. It meets most of the criteria listed above but does not provide a procedure for preparing systems control orders in automated format. U.S. Eighth Army has retained the signal organization of the Korean War period. Its methods of systems control also differ greatly from those of FM 11-21, but have been developed specifically for use on the Korean peninsula and do not appear generally applicable to the 1965-1970 field army. The U.S. Army Combat Developments Study, Improved Applications of Manual Signal Systems Control and Signal Information Service, for the Field Army Command and Area Communications Systems, 1965-1970 (U),

outlines an organization for systems control that is fully compatible with the modern field army signal organization, but its procedures utilize records, reports and orders that are not particularly concise nor applicable to manual methods of systems control. The U.S. Defense Communications Agency uses a fully-developed automatic data processing system to carry out its communications control functions. However, its control programs are designed to be applied to a multi-service world-wide communications network rather than a tactical system.

It is apparent that none of these procedures meet all of the criteria for an adequate tactical systems control doctrine. A new doctrine is proposed which is simple, concise and effective. It retains the desirable elements of the previous systems control methods and introduces new techniques for those areas where previous procedures have been found to be inadequate. The doctrine is tested within the framework of a type large-land-mass field army to determine the ability of the suggested procedures to react promptly and effectively to the ever-changing aspects of combat. The proposed doctrine is seen to provide a means for accomplishing the day-to-day control of the field army communications network using manual procedures which are easily converted to automatic data processing methods.

The impact which the introduction of automatic data processing systems and automatic circuit switching equipment will have on the post-1970 field army is analyzed. Both

techniques are seen to complement each other: automatic data processing equipment will greatly reduce the time and effort necessary to formulate and carry out systems control actions, while automatic circuit switching will eliminate one of the major tasks of the systems control element, that of individual circuit identification and control.

The proposed doctrine developed in this thesis offers significant advantages over the previous methods of systems control. It provides clear and positive operating guidance for the field army systems control center and subordinate battalion control centers. Systems control actions are taken at the lowest possible level to provide flexibility in controlling the field army communications network. Centralized control is maintained by a system of simple and concise reports which gives the field army systems control center up-to-date information about the status of the field army network and its components. Application of this systems control method to the field army communications network will materially assist the signal brigade commander in the accomplishment of his mission to provide signal communications for the field army.

The author was commissioned in the Signal Corps upon his graduation from Cornell University in 1953. He has served with the Military Assistance Advisory Groups in Taiwan and Iran. Prior to entering the U.S. Army Command and General Staff College he served as the deputy signal officer of U.S. Army Japan.

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A PROPOSED DOCTRINE FOR FIELD ARMY COMMUNICATIONS SYSTEMS CONTROL

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements of the degree

MASTER OF MILITARY ART AND SCIENCE

by
CLARE R. J. ROGERS, MAJ, USA

Fort Leavenworth, Kansas
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Memo dtd 15 Jul 99

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U.S. ARMY COMMAND AND GENERAL STAFF COLLEGE

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I am grateful to the U.S. Army Command and General Staff College for extending to me the opportunity to participate in the Graduate Program. Until I began to study the problem of communications systems control my knowledge of this vital area of signal operations was negligible. The Graduate Program has helped me to become a better writer and a better signal officer.

My deepest appreciation is extended to Lieutenant Colonel Charles J. Norris, my faculty advisor and thesis monitor. His constructive criticism, editorial assistance, and encouragement were invaluable to me throughout the research and writing of this work.

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for their descriptions and explanations of the systems control procedures of U.S. Seventh and U.S. Eighth Armies; and to Mrs. John Vilas, who patiently and painstakingly typed this paper.

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INTRODUCTION

A commander without communications is only as effective as the range of his voice. Control of the diversified and widely-scattered elements of the modern army demands swift, reliable, and secure means of communication to make the commander in fact what he is in name.

The United States Army Signal Corps describes itself proudly as the "arm of command control." Its personnel, units, and organizations are furnished to commanders at each echelon to provide them with the capability of directing their forces in the accomplishment of their mission.

Signal organizational commanders, like all other commanders, are faced with problems of personnel administration, intelligence, operations, and logistics--the traditional coordinating staff functions of the S-1, S-2, S-3, and S-4. But though the problems of personnel, intelligence, and logistics at the organizational level have not changed drastically over the years, the problem of signal operations has grown more and more complicated with the introduction of new, complex, and ever-changing machines and equipment.

This complexity is seldom reflected in the mission assigned to the signal commander. Unlike a tactical

organization, whose mission is usually spelled out in great detail and which differs with each change in the many variables that affect combat operations, the signal mission is usually general and stereotyped in nature. A typical mission for the field army signal organization may be given as follows:

> Install, operate and maintain the army area communication system and provide terminations for all major elements of the command. Provide signal combat service support and manipulative communications deception support for the army. Initial system to be in operation by 021500 March.[1]

With a change in the time of initial operation this mission statement might well serve as a task assignment for any field army signal organization in any part of the world under almost any tactical situation. It is obvious that this mission statement says nothing about the many factors which must be completely integrated and coordinated by the signal organization commander if his mission is to be accomplished.

The primary areas of signal concern are communications, electronics, and photography. The communications functions consist of electrical, electronic, and messenger service.[2] In planning how communications tasks will be

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[1]U.S. Army Command and General Staff College, "Signal Annex to Operation Order, Army," Staff Organization and Procedures, ST 101-5-1, (Fort Leavenworth, Kansas: April 1966), p. 353. (Fort Leavenworth, Kansas Library).

[2]U.S. Department of the Army, "Change 1, (7 February 1964)," to Field Service Regulations--Operations, FM 100-5 (Washington: U.S. Government Printing Office, February 1962), p. 8.

accomplished and in insuring that they are satisfactorily carried out the signal officer looks to his operations staff element for assistance.

To a very real extent signal operations exist in two worlds. One is the tactical world, concerned with insuring the security of the signal organization against enemy attack. The second is the technical world, occupied with the problem of assuring the technical adequacy and reliability of signal combat support. Technical control of signal communications includes the following activities:

1. Traffic engineering and analysis.
2. Transmission and circuit engineering and circuit control.
3. Systems engineering.
4. Organization and assignment of personnel.
5. Allocations of equipment, facilities, and operating units.
6. Issuance of communications orders, and conduct of operations.
7. Establishment of standing operating procedures (SOP).
8. Frequency control and allocation.
9. Routing, directory, and information service.
10. Inspection.
11. Maintenance.[3]

This paper examines one area of signal operations: the technical problem of day-to-day control of the electrical and electronic communications systems within the field army.

Field army communications systems have grown and multiplied many times since the first crude attempts at

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[3]U.S. Army Electronic Proving Ground, "Appendix 1, Basic Concepts of Communications and Facilities Control, to Annex H, Communications Systems and Facilities Control," Development of the Communications System and Equipment Integration Plan for the Field Army, 1962-1965 (U), SIG CCD 58-4, (Draft Report; Fort Huachuca, Arizona: October 1960), Vol. IV, H-1 pp. 3-4. (File No. N-18538.12-D, Fort Leavenworth, Kansas Library).

long-distance signaling in the nineteenth century and will again increase manifold within the next decade. To provide an understanding of the magnitude of the systems control problem and its complexities the development of tactical electrical and electronic communications systems is examined and their technical characteristics and functions are discussed. The communication requirements which they must satisfy within the 1965-1975 time period are computed and the present doctrine and various methods which have been developed over the years for systems control are reviewed. A new doctrine of communications systems control as developed in this paper is tested within the framework of the field army of the future. Conclusions are drawn concerning the new doctrine which has been developed.

It is hoped that the results of this study will be of use to those officers and men concerned with communications systems control in support of the future army in the field, and that the doctrine as developed in this paper will provide the basis for systems control procedures applicable throughout the U.S. Army.

CHAPTER I

IN THE BEGINNING

Garrison life in the small cantonments along the Rio Grande was probably not very exciting in the years just before the Civil War. Idle hours and consequent boredom must have been one of the major occupational hazards of the soldier, and especially so for the officers of the U.S. Army's Medical Department, whose duties were very likely confined in large part to vain attempts at curing hangovers brought on by overindulgence in frontier whisky.

One such medical officer thrown upon his own resources for amusement was Dr. Albert J. Myer, who had obtained his degree as a Doctor of Medicine from the University of Buffalo in 1851 on the strength of a thesis entitled "A New Sign Language for Deaf Mutes," was commissioned an Assistant Surgeon in the U.S. Army in 1854, and eventually was stationed at Fort Duncan, Texas. In the spare time at his disposal, Dr. Myer adapted his system of visual communication for deaf mutes into a method of signaling by flags.[1]

By 1860 the value of Dr. Myer's work had been recognized, at least to a certain extent, for on 21 June of that

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[1] Dulaney Terrett, The Signal Corps: The Emergency ("United States Army in World War II: The Technical Services"; Washington: U.S. Government Printing Office, 1956), pp. 9-10 and note 13.

year the position of Signal Officer was established by Congress and Dr. Myer was appointed to the vacancy thus created.[2] His duties were broad in scope, probably because no one knew exactly what a signal officer was supposed to do. The Army Regulations of the time gave them as follows: "1063. The signal officer shall have charge, under the direction of the Secretary of War, of all signal duty, and of all books, papers, and apparatus connected therewith."[3] Dr. Myer's appointment as signal officer for the U.S. Army was a milestone in the science of military communications. For the first time anywhere in the world a full-time signaling function as a part of a national army had been established.[4]

Both the U.S. Army Signal Service and military communications expanded greatly in the Civil War. Electrical means of communications were used for the first time on the battlefield. These included the telegraph systems operated by the U.S. Military Telegraph System, a private corporation, and the Beardslee Magneto-Electric Telegraph Set, operated by the army. However, these were located far to the rear for the most part. Tactical communications remained the province of visual signals for years to come. An improved

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[2]John D. Billings, Hardtack and Coffee (Boston: George M. Smith & Co., 1888), p. 395.

[3]U.S. War Department, Revised Regulations for the Army of the United States, 1861 (Philadelphia: J.G.L. Brown, 1861), p. 157.

[4]"Army Signals Through The Years," Army Information Digest, XVIII, 5 (May 1963), p. 40.

type of heliograph was introduced into the army as late as 1888.[5]

The telephone was given its initial military trial in 1878, and field tested in 1889. It was a rather complicated and delicate instrument for those days of rough-and-ready soldiering, and most important of all it was felt to be too expensive for the services provided.[6] Although the Field Artillery had been using the telephone since 1905, there was little equipment available for the American Expeditionary Force when the United States entered World War I. Had it not been for large-scale purchases of French communications equipment the AEF would hardly have been able to communicate.[7]

Radio made its first appearance in the Signal Corps in 1899. Like the first telephone sets, radio equipment was expensive; in addition, it was heavy, bulky, and difficult to keep in working order. Due to these shortcomings radio was little used in World War I.[8]

With the termination of the "war to end war" the requirement for military communications almost terminated. From a strength of 34,500 personnel at the time of the Armistice the Signal Corps dwindled to 2,184 officers and men in 1922.[9]

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[5]Terrett, p. 11.

[6]*Ibid*. [7]*Ibid*., p. 12. [8]*Ibid*., pp. 16-18.

[9]*Ibid*., pp. 21-22.

What need was there for a larger force? The defense of the nation, the army's principal mission, was predicated on the assumption that it would be carried out on the United States' own soil. Other than the requirement for short-range tactical communications, the sophisticated systems of the Bell Telephone Corporation, Western Union, Postal Telegraph, and others would be more than adequate for higher-level military needs. In 1930 the Signal Corps envisioned a minimum requirement for thirteen local telephones at corps main headquarters, with a possible requirement for an additional five to seven lines if corps staff sections such as the meteorological section, medical service headquarters, engineer headquarters, the headquarters commandant, provost marshal, and the pigeon lofts were located at the main corps command post. At corps rear echelon a minimum of ten telephones was considered adequate.[10]

Long lines required by the corps included two telephone circuits with one superimposed (simplexed) telegraph circuit to each division and to corps rear echelon, three lines with superimposed telegraph circuits to army headquarters, and one line each to the corps reserve, corps artillery, and other organizations attached to the corps. In addition, a telephone line to corps artillery trains

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[10] U.S. Army Signal School, Tactics and Techniques of Signal Communication for the Corps, Army, and Communications Zone ("Signal School Pamphlet No. 24"; Fort Monmouth, N.J.: 1930), p. 53. (File No. M411 J1 C, Fort Leavenworth, Kansas Library).

and one to the corps railhead with superimposed telegraph from the corps rear echelon were considered necessary. For a type corps, the corps signal officer was expected to satisfy a requirement of approximately thirty local, eighteen long-distance telephone, and seven long-distance telegraph circuits.[11]

The U.S. Army Signal Corps was not expected to concern itself greatly with the provision of men and equipment for the installation of these systems.

> The corps wire system will generally consist of wire circuits and exchanges of the existing commercial systems that the army signal officer has allocated for the use of the corps with such additional facilities as may have to be provided by the corps signal battalion to meet the requirements of the corps. . . . When the corps takes over a commercial telephone central, it is generally necessary to operate it with signal corps personnel.[12]

Radio, with the exception of air-to-ground and cavalry communications, was considered an emergency means of communications only. The type corps was expected to operate a command net with seven stations, an air-to-ground net, a corps artillery net, and a corps anti-aircraft artillery net, with three stations each in the latter two nets. The corps also operated a station in the army command net.[13]

At army level the communications requirements were of necessity much greater. The total radio nets within an army area, counting corps and divisions, amounted to approximately 266. Supervision and control were an obvious necessity if these nets were to operate at maximum efficiency and

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[11]*Ibid.* [12]*Ibid.*, pp. 50, 53. [13]*Ibid.*, p. 51.

provide the communications which the army required. The control requirement was broken down into three areas: the requirement to assign frequencies so that one net would not interfere with another; the requirement to insure that proper operating procedures were observed to achieve the same end; and the requirement to silence certain less-essential nets so that more vital ones could continue to operate without interruption. These control requirements were generated by the limited frequency range of the radio sets that were available and the overcrowding of the radio spectrum within that frequency range. The planners of the 1930's hoped that new developments in radio then under investigation would prove successful, for then the control requirement would no longer exist. "The signal officer will then only be concerned with silencing nets to prevent the enemy from gaining information as to the disposition and movements of friendly troops."[14]

Telephone and telegraph communications requirements for the army, as in the case of the corps, were expected to be satisfied by reliance on commercial communications facilities. Local circuits required at the forward and rear headquarters echelons were estimated at 100 to 500 lines, connected to at least two separate switchboards with branch switchboards installed as required. For example, the army G-4 section, which had a great deal of traffic between its elements and supply installations, might well require its

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[14] Ibid., pp. 49, 58-59.

own exchange to relieve the burden on the main army switchboard.[15]

Army long-distance circuit requirements were as hard to estimate as were the requirements for local telephone service, but it was felt that 50 to 100 long-distance telephone circuits and 50 to 20 telegraph circuits were needed.[16]

By 1937 circuit requirements had been revised upwards. A type corps main headquarters would now require approximately forty long-distance telephone circuits and twenty-five telegraph circuits; corps rear echelon approximately fifteen long-distance telephone and eight telegraph lines. The army was still dependent on the existing commercial systems for its communications.[17]

To be sure, there were some who doubted that commercial communications would be able to meet the army's needs. Communications between division and corps were beset with problems during the spring maneuvers of the IV Corps at Fort Benning in 1940 in spite of the fact that the area had commercial communications. A Signal Corps observer made the following comment: "It is doubtful whether much reliance can be placed in time of war on the extensive use of commercial communications systems," adding the thoughtful note "especially in areas where the civilian population is

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[15] Ibid., p. 63. [16] Ibid., pp. 68-69.

[17] U.S. Army Command and General Staff School, Signal Communications, (tentative; Fort Leavenworth, Kansas: 1937), p. 33. (File No. M411 J1, Fort Leavenworth, Kansas Library).

unfriendly."[18] That was an isolated observation, however. The total requirements for field wire to equip a 1,000,000-man army were set at 22,000 miles in 1940, revised upwards to 80,000 miles in 1941, and still fell far short of what was actually to be needed.[19]

A year later the possibility of utilizing commercial communications became more uncertain as a result of the experience gained in the Second and Third Army maneuvers of 1941. The serious gap in the wire communications systems available to the army became more apparent. Field wire was adequate within a divisional area. The maximum telephone transmission range for the standard field wire, W-110, was eighteen miles, but this dropped to about ten miles if the wire became wet, which it did with each passing rainstorm.[20] There were no adequate facilities to connect the division with higher headquarters if commercial communications means were not furnished except the military equivalent of the commercial open-wire line. This consisted of bare copper wires suspended from poles. It was exceptionally slow and difficult to construct and required an excessive amount of heavy construction materials as well.

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[18] Lt. Col. Edgar L. Clewell, "Signal Communications in Fourth Corps During Spring Maneuvers, 1940," Signal Corps Bulletin, No. 109 (July-December 1940), pp. 31-32, quoted by Terrett, p. 153.

[19] Terrett, pp. 176, 241. Cf. his note 34 p. 16.

[20] Officers' Department, The Signal School, Electrical Characteristics of Field Wire, ("Information Sheet W08-250-4"; Fort Monmouth, New Jersey: n.d.). (File No. P 11.7, Fort Leavenworth, Kansas Library).

Just around the corner was a new development that was to remedy the lack of suitable communications between army, corps, and division. A new type of field cable had been developed by the Germans, captured by British Commandos, and turned over to the Signal Corps Laboratories under the information-sharing agreement worked out between the British and U.S. governments.[21] It consisted of four conductors which were wrapped around a central fiber core, encased in a woven wire shield, and insulated with rubber. The U.S. lost no time in manufacturing its own field cable to this pattern. Because of its spirally wrapped four conductors the U.S. version acquired the common nickname of "spiral-four cable." Its official U.S. designation was forgotten except by supply officers and others fond of precision. The numerous reasons for its superiority as a communications medium are highly technical and outside the scope of this work, but it increased the distance over which a conversation could be carried using the EE-8 field telephone, the army's standard instrument, from eighteen miles to forty miles.[22] This was over twice the range of W-110. Spiral-four cable as adopted by the U.S. Army came in one-quarter mile lengths equipped with plastic snap connectors, so that the time-consuming requirement for splices was eliminated and the electrical

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[21] Terrett, p. 241.

[22] Officers' Department, The Signal School, Characteristics of Field Cable ("Information Sheet W08-251-2A"; Fort Monmouth, New Jersey: n.d.). (File No. P 11.7, Fort Leavenworth, Kansas Library).

characteristics of the cable were maintained. The relative ease of installation made it possible to establish communications between higher tactical headquarters under combat conditions with a rapidity previously unthinkable, particularly to those whose experience centered around open wire systems mounted on carefully constructed pole lines.

Another development was to free the army from its dependence on the buzzer of the hand-operated telegraph set. By 1940 a new device, sometimes called a printing telegraph but more commonly known as a teletypewriter, was about to assume the lion's share of the signal burden. Interestingly enough, the problem in adopting this form of communication for the army did not center around the fantastically-complicated printing equipment itself, a commercial version of which turned out to be readily adaptable to military needs, but was rather concerned with the provision of a reliable field generating set to provide stable electric power.[23] Tested and proven in the maneuvers of 1940, the army model began rolling off the production lines in early 1942.[24] This equipment was capable of printing messages at a rate of sixty words per minute, hour after hour, in contrast to the slow and laborious key-pounding of the manual telegrapher who rarely exceeded fifteen words a minute, who

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[23] Terrett, p. 115.

[24] _Ibid._, p. 154.
George Raynor Thompson _et al._, _The Signal Corps: The Test_, ("United States Army in World War II: The Technical Services"; Washington: U.S. Government Printing Office, 1957), p. 64.

required extensive training, and who tired rapidly. Like its hand-operated predecessor, the teletypewriter proved invaluable in enabling the U.S. Army's communicators to cope with the torrents of administrative and logistic messages which a global war and a global army produced.

The facsimile set, while not destined to become a communications instrument of major importance, was to be employed by the U.S. Army for the first time in World War II. An adaptation of the commercial press services' wirephoto equipment, the facsimile set offered the possibility of electrical transmission of tactical and weather maps, charts, and other documents which required exact reproduction at the receiving location in order to employ them and utilize the information which they contained.[25] Eventually standardized and built to military specifications, the same equipment continues in use today.

The number of metallic conductors between two points still limited the U.S. Army's communications in the early stages of World War II. As far as the army was concerned it made little difference whether the wire lines were composed of field wire, spiral-four cable, or open wire. The rule remained the same--one pair of wires, one telephone conversation.[26] In spite of the fact that a

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[25] Ibid., p. 453.

[26] It is possible to obtain an additional circuit or two by special methods, but the resulting circuits are apt to be noisy, easy to intercept, or both. For this reason the Signal Corps has preferred not to use this system except occasionally for telegraph.

future Chief Signal Officer of the U.S. Army, Major General George O. Squier, had invented a system for superimposing several telephone conversations on a pair of conductors as early as 1911, the Signal Corps had neglected this development entirely.[27] With the pressure of war now upon them, the Signal Corps Laboratories began to study the application of General Squier's "wired wireless" to military communications more closely. This system was based on the same principle that allowed numerous radio stations to transmit at the same time by using different frequencies, with the basic difference that the electrical signal was carried on wires rather than radiated through space. Commercial communications companies had been utilizing it for some time. As finally developed for the U.S. Army in the spring of 1942 the equipment comprised a system of amplifiers together with three low-powered transmitters, each with its associated receiver, which emitted three separate frequencies for transmission along the connected wire lines. The incoming signal from a telephone was mixed with the fixed frequency of its assigned transmitter, and the resulting composite signal transmitted to the distant terminal over a suitable wire line. There a receiver operating on the same frequency "unscrambled" the signal and reproduced it in a form that an ordinary telephone could use to produce recognizable speech. When the listener

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[27] George O. Squier, Multiplex Telephony and Telegraphy by Means of Electric Waves Guided by Wires ("Professional Paper of the Signal Corps, U.S. Army, War Department Document No. 390"; Washington: U.S. Government Printing Office, 1911.)

at the distant end wished to answer his caller the process was reversed, using identical equipment. Due to the use of fixed frequencies to "carry" the signal from the telephone to the desired location this equipment received the name "carrier equipment." It was officially designated the CF-1. Additional devices were developed such as amplifying equipment that repeated the signal and signaling equipment to activate the bell on the telephone. Telegraph terminals which used the same principles to combine several telegraph circuits were developed. The CF-1, the newly-developed spiral-four cable, and these devices in combination became known as the "100-Mile Spiral-Four System." Employed in a type role, it provided three telephone and four two-way telegraph circuits for a nominal distance of 100 miles over spiral-four cable.[28]

In the spiral-four carrier system the Signal Corps now had a means of communications that was more efficient, lighter, and easier to install than open wire, but it was still not adequate for the needs of a fast-moving, far-flung army. The tactics of the blitzkrieg had proven conclusively that an army's speed was no longer to be measured by the pace of a marching infantryman. Wherever the headquarters went, communications must follow; and there were streams to be crossed, rivers to be forded, and mountain ranges to be crossed. Wire and cable, improved though they might be,

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[28] Thompson, pp. 64-68.

could still not be installed with the speed that the army's new mobility demanded.

The answer was radio. The engineers of the Signal Corps Laboratories had mentally considered the application of radio to provide a rapid means of linking wire lines interrupted by water and land obstacles. After some prodding by the Army Air Forces, considerable discussion, and investigation which lasted throughout the summer of 1942, the Signal Corps General Development Laboratory found a commercial piece of radio equipment, the Link Model 1498, which gave promise of meeting all requirements. The Link set was frequency modulated (FM), which meant that it did not use as large a share of the crowded radio frequency spectrum as an amplitude modulated (AM) set. Under normal conditions its waves would not carry far beyond the horizon, thus limiting the distance between the two sets to the line-of-sight path between them. This characteristic insured that one radio link would not interfere with a more distant one, and so permitted the same frequency to be re-used several times within a relatively confined geographical area. In addition, fading of the received radio signal was almost non-existent and atmospheric static did not affect the quality of the transmission. Best of all, the new equipment would work with the army's new telephone and telegraph carrier systems. Standardized and given the joint Army-Navy type number of AN/TRC-1, standing for "Army-Navy (ground) Transportable Radio Communications (set number) One," the new radio soon

became known and used throughout the Signal Corps as "radio relay," or more popularly as "track-one" from the attempt to pronounce its type number. While it found a use in its original role as a means of continuing wire lines over obstacles, in most cases radio relay was used to eliminate the need to install wire.[29]

By mid-1943 carrier, cable, and radio relay--the essential types of equipment that would elevate military communications to the level reached by the commercial companies--were in the field and operating. The concept of responsibility for communications had not changed. The field army would provide circuits down to the corps, which in turn would install its circuits down to the division level. The requirements for communications had expanded by a factor of four. A type corps at the end of World War II needed about sixty-five long-distance telephone and thirty telegraph circuits to meet normal requirements for communications between army, corps, and division.[30] This expansion had taken place in spite of the fact that written messages were being passed more than four times as fast as had been possible at the start of the war. The Signal Corps, as it looked to the future, could find every indication that expanding science and technology would not only bring new equipments, methods, and

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[29] Ibid., pp. 234-237.

[30] Officers' Department, The Signal School, Communications Tactical Wire Records Reference Data ("Instructional Material W14/1"; Fort Monmouth, New Jersey: 15 October 1952), p. 12. (File No. P 11.4, Fort Leavenworth, Kansas Library).

organizations to the battlefield, but would also bring greatly increased requirements for speedy, secure, and efficient communications.

CHAPTER II

THE TACTICAL COMMUNICATIONS NETWORK

The word "communication" has several definitions. Perhaps one of the best descriptions of "communication" as it applies to the work of the Signal Corps was contained in the contract between the Chief Signal Officer and the Franklin Institute of Philadelphia which called for an operations research study of army communications. As defined therein, "communication" is the technique "of conveying information from its point of origin as human thought through its dissemination to the points of action."[1] In conducting the study, the authors established six steps in the communications process: the originating of a thought in the mind of an action officer; the conversion of the thought to language, which may now be called a <u>message</u>;[2] the coordination of the message with other individuals; review and release of the message, which involves the approval of the action officer's superiors; staff communications control, wherein the message

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[1] Joel M. Bloom, Clifton E. Mayfield, and Richard M. Williams, <u>Modern Army Communications</u>, (Final Report, Contract DA 36-039-sc-78332; Philadelphia: The Franklin Institute, January 1962), p. 1. (File No. 627.73 B 655m, Fort Leavenworth, Kansas Library).

[2] U.S. Department of the Army, <u>Communications: Communications Economy</u>, AR 105-10, (Washington: U.S. Government Printing Office, 17 June 1965), p. 1.

is processed within the headquarters, generally involving the clerical process of insuring correct format, recording the message, and preparing it for transmission; and the actual transmission of the message by the inter-headquarters transmission (signal communication) element. At the destination of the message these steps are traversed in reverse until the receiving action officer has established the contents of the message as a thought in his mind.[3]

Messages may be either formal (official) or they may be informal (unofficial).[4] The official message has the approval, express or implied, of the commander and represents his reasoned judgment on the problems at hand. It originates as part of the staff function to prepare plans and orders for execution by subordinate units or to assist the commander in providing information or recommendations for submission to higher authority. The unofficial message originates as part of the staff function to collect or provide information which will eventually serve as the basis for formal action on the part of the commander. Obviously, not all of the steps in the communications process are required for all messages. For example, the staff officer

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[3]Bloom, pp. 2-3, 73.

[4]This distinction seldom occurs in U.S. Army publications. An example, where the difference between official and unofficial messages is repeatedly stressed, is found, however, in U.S. Army Strategic Communications Command, Staff Service Message Policy and Procedure Bulletin No. 8, (Washington: October 1965), pp. 1, 3. (In the files of the U.S. Army Strategic Communications Command, Fort Leavenworth, Kansas Facility).

placing a telephone call to obtain information from a subordinate unit may not discuss his thoughts with other staff officers beforehand; the commander who issues instructions personally does not obtain review and approval of his orders before issuing them; and the clerical procedure of checking for correct format is hardly applicable to telephonic communications.

It is also necessary to differentiate between recorded messages and non-recorded messages. A recorded message provides the recipient with information in a form to which he can refer whenever he chooses. The non-recorded message is received and then is lost forever, except as the originator and the recipient may remember it. Both types have existed in armies from the beginning; the written directive or order carried by messenger to its destination, and the oral directive issued by the commander or through a staff officer dispatched for the purpose. Both methods of communications are still very much in use today. Military letters pass between headquarters and individuals in great volume. The commander and his staff officers still visit subordinate commanders and their staffs to tell them what they are required to do or to gain information.

With the development of modern means of communications, however, it became possible to shorten drastically the amount of time required to convey information from one point to another. General Myer's system of signals, the telegraph, and its successor the teletypewriter all provided

a means of exchanging recorded communications rapidly over great distances. The telephone became the preferred method for exchanging non-recorded messages.[5]

A message may be either formal or informal, and it may be presented to the signal communications element for delivery to the recipient in recorded or non-recorded form. It will generally be accompanied by a statement of its urgency (precedence), or the amount of delay that can be tolerated before the message is delivered to its destination.[6] The signal communication element is not concerned with the formal status of a message, but the statement of urgency is another matter.[7] Complying with its demands is an important signal function.

As soon as the signal communications element receives a message, it is charged with the responsibility for delivering the message to the recipient in the form and within the time specified. The first determination that the signal element must make is the means of communications that will satisfy this requirement.

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[5]The development of the wire and the tape recorder makes it possible to provide a permanent record of a telephone conversation, but this is rarely done. Cf. Bloom, p. 25.

[6]Ibid., p. 74.

U.S. Department of the Army, Communications: Message Preparation, AR 105-31, (Washington: U.S. Government Printing Office, 19 August 1965), pp. 4-1, 4-2.

U.S. Department of the Army, Communications: Unclassified Voice Communications, AR 105-12, (Washington: U.S. Government Printing Office, 6 June 1966), pp. 3-5.

[7]Bloom, p. 71.

Traditionally, the "means of signal communication" have been messenger, wire, radio, visual, sound, or pigeon communications.[8] In today's modern army the traditional definition offers little assistance in determining how the message will be transmitted. For example, messenger service as operated by the signal communications element affords the dispatch of recorded communications only. Radio and wire may provide both recorded and non-recorded communications. It is more accurate to consider the "means of signal communication" as representing only one element of the military communications network--the transmission facilities that provide a path or channel for the message to follow between the originator and the recipient. A second element of the military communications network, the terminal instrument, must be examined first.

The initial task of the signal communications element is to choose, from the devices available to it, one which will meet the originator's statements of urgency and format. These devices, or terminal instruments, are mechanisms that receive the message as prepared by the originator and convert it into a form suitable for transmission onward, or receive a signal and convert it into a form intelligible to the recipient. The electrical terminal instruments available to the army include those developed prior to or

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[8] E.g., U.S. Army Command and General Staff School, Tactical Signal Communication for Commanders and General Staff Officers, (Fort Leavenworth, Kansas: 24 February 1944), p. 17. (File No. M 411 J1, Fort Leavenworth, Kansas Library). Pigeons no longer serve with the U.S. Army.

during World War II, the telephone, teletypewriter, and the facsimile set. Among the post-war developments, data transmitting and receiving instruments (transceivers) are assuming a major role in communications, and television gives promise of increasing military applications in the future.[9] The telephone and the television set are generally made available at the message originator's location. The remaining devices, due to their complexity, expense, and requirement for special processing of the message before transmission or after reception are usually centrally located and operated by the signal communications element.

It is apparent that in some cases the choice of terminal instrument is dictated by the transmission facilities to which the terminal instrument is connected. A teletypewriter or a telephone connected to a radio set is useless if the radio does not work. To provide flexibility and avoid this "all or nothing" aspect of communications, some form of controlled interconnection is required between terminal instruments, the transmission facilities available to them, and between the various transmission facilities themselves. These controlled interconnection devices or switching arrangements form a third element of the communications network. The most familiar electrical switching device is the common switchboard, developed almost

[9]U.S. Department of the Army, Electrical Communications Systems Engineering: Military Communications Systems, TM 11-486-1, (Washington: U.S. Government Printing Office, September 1956), p. 6-1.

concurrently with the telephone and applied to other forms of electrical terminal instruments.

The switchboard contains, in addition to its switching circuitry, the fourth element of the communications network, signaling arrangements. These direct the switching operations of the electrical communications system and in general control the operations of the entire communications network.[10] On the switchboard the signaling arrangements take the form of supervisory lamps, drops, night alarms, etc. An ordinary telephone uses a bell as its signaling device.

Of the four major elements of a communications network--the terminal instrument, the transmission facilities, the switching elements, and the signaling arrangements --the most variable and the most laborious to install, operate, and control are the transmission facilities. In order to understand the communications network they must be examined in greater detail.

When the scientific and technical world began an investigation of the physical laws which govern the operation of the telephone, it found that although human speech contains frequencies from about 60-8,000 cycles per second and the human ear can detect frequencies lying within the band from 0-20,000 cycles per second (the audio frequency band), the telephone did not have to reproduce this entire band of frequencies in order for a conversation to be understood.

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[10] Ibid.

Generally speaking, a frequency band of about 300-3,200 cycles per second was found to be entirely adequate for high-grade telephone service.[11] Any transmission facility which could carry this band of frequencies was spoken of as providing a telephone channel.[12] To provide separation between channels when several were provided by one system, as in the case of a telephone carrier system, a telephone channel was nominally assigned a bandwidth of 4,000 cycles, even though the signal which it carried might not require the full frequency range of the channel. The portion of the frequency band not used served to prevent interference between adjacent channels. A telephone channel of this type is often described as a four-kilocycle (4-kc) channel and is the basic building block for military transmission facilities.[13]

In comparison with the telephone, the teletypewriter produces an electrical signal with an effective frequency range of about 50-60 cycles per second. In this form it is not suitable for transmission over telephone multichannel carrier systems, since the latter will not generally accept frequencies below 300 cycles per second. In order to pass telegraph signals over this type of system a device must be

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[11] _Ibid._, pp. 6-4, 6-5.

[12] U.S. Department of the Army, "Telephone Channel," _Electrical Communications Systems Engineering: Definitions and Abbreviations_, TM 11-486-11, (Washington: U.S. Government Printing Office, January 1957), p. 2-320.

[13] U.S. Department of the Army, _TM 11-486-1_, pp. 6-5, 6-9.

used to convert the low-frequency signals from the teletypewriter machine into higher frequencies which are capable of transmission over a telephone channel.[14] With the development of the U.S. Army's first carrier equipment, the CF-1, it was recognized that more than one teletypewriter signal, consisting as it did of a very narrow band of frequencies, could be accommodated within the wider bandwidth of one telephone channel. In order to take advantage of this fact as well as to convert the teletypewriter signal to a higher frequency the CF-2 teletypewriter carrier equipment was developed. It provided four teletypewriter channels which could be operated simultaneously in each direction over one telephone channel of the CF-1. The next generation of teletypewriter carrier equipment which followed, the AN/TCC-4 and its components, provided up to 16 teletypewriter channels over one 4-kc telephone channel.[15]

Signaling devices share similar problems with teletypewriter equipment. As originally developed for telephone use and still employed today, the usual signaling device produces a current with a frequency of about 20 cycles per second. This will not pass over a telephone channel of a military multichannel system due to its low frequency, as explained above. A device known as a ringing converter,

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[14] Ibid., pp. 6-4, 8-15.

[15] U.S. Department of the Army, Electrical Communications Systems Engineering: Transmission and Circuit Layout, TM 11-486-3, (Washington: U.S. Government Printing Office, December 1956), App. 1, p. I-22.

commonly shortened to "ringer," must be inserted in the circuit at both ends of the channel to convert the low-frequency current from the telephone or switchboard into higher frequencies for transmission over the telephone channel and reconvert it to activate the signaling device at the distant end.[16]

Facsimile and punch-card data transmission devices have been specifically designed to be compatible with the frequency range of telephone or teletypewriter channels. Television, on the other hand, requires a bandwidth from about 30 to 4,000,000 cycles per second. Transmission facilities for television represent a special requirement that must be closely examined and carefully engineered for each particular situation.[17]

In addition to the frequency bandwidth of a communications channel, three other important characteristics must be examined. These are attenuation (loss), crosstalk, and noise.

Attenuation is the loss of power that occurs due to the fact that transmission lines are not perfect conductors. Power losses in a wire line generally occur as a result of the resistance along the line and leakage due to imperfect

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[16]U.S. Department of the Army, TM 11-486-1, p. 7-16.

[17]Ibid., pp. 6-4, 6-5, 10-2, 10-13. The figure of 3,5550 cps given on p. 6-5 is incorrect. The proper frequency is 3,550 cps. Cf. p. 10-6.

U.S. Department of the Army, Communications-Electronics Reference Data, FM 24-19, (Washington: U.S. Government Printing Office, October 1966), p. 78.

insulation. For communications engineering purposes these losses are specified as the ratio of the input power to the output power. The initial unit of measurement was named the bel in honor of Alexander Graham Bell, the inventor of the telephone, and represented a power ratio of ten to one. In a circuit where ten watts of power is applied at one end and only one watt is available at the distant end the loss is said to be one bel. The bel was found to be an unduly large unit of measurement. A smaller unit, the decibel, or one-tenth of a bel (abbreviated db) was adopted. Since the decibel expresses only power ratios, not power, and since losses over a given transmission facility increase with an increase in the frequency of the signal, it was found advantageous to measure losses in telephone circuits by reference to a standard frequency of 1,000 cycles per second and a standard input power of one-thousandth of a watt (one milliwatt). The unit used for this measurement is the decibel referred to one milliwatt (abbreviated dbm).[18] Common telephone engineering practice usually, if erroneously, expresses losses in db, the other parameters being accepted as understood. The use of db or dbm as a yardstick greatly facilitates system engineering by making it possible to express the total loss of a

[18]U.S. Department of the Army, TM 11-486-3, p. 2-7. The measurement of power in dbm is actually independent of frequency.

circuit (the circuit net loss) by adding the losses of each segment of the circuit.[19]

With the application of amplifying equipment to electrical communications systems it would seem possible to provide by amplification an output power at the distant end of the transmission facility equal to the output power, since the amplifier can produce a gain in the signal level. Such a circuit would be said to have a circuit net loss of 0 db.[20] In actual practice various imperfections in most transmission facilities and the characteristics of the transmission facilities themselves limit the minimum circuit net loss to about 3 db. Based upon the characteristics of the present field telephone, the TA-312/PT, the maximum circuit net loss that can be tolerated without loss of intelligibility is 36 db.[21]

Crosstalk and noise are the characteristics of a transmission facility that occur when a voltage or current not part of the desired signal is developed in the circuit. If the voltage or current is intelligible, it is called crosstalk; all other disturbances are called noise. Both

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[19]U.S. Department of the Army, Fundamentals of Carrier and Repeater, TM 11-679, (Washington: U.S. Government Printing Office, December 1953), pp. 204-214.

[20]Here the ratio of the input power to the output power is 1/1, or 1. One db equals ten times the common logarithm of the power ratio, which has a value of zero in this case ($\log_{10} 1=0$).

[21]U.S. Department of the Army, TM 11-486-3, p. 14-14. U.S. Army Signal School, Tactical Telephone and Telegraph Communications Equipment, ST 24-20-1, (Fort Monmouth, New Jersey: 15 January 1962), p. 3. (File No. P 11.4, Fort Leavenworth, Kansas Library).

crosstalk and noise must be considered in engineering circuits. Their effects are called the signal-to-crosstalk and signal-to-noise ratio, representing the ratio between the desired signal level and the unwanted signal level. Both ratios are expressed in db, the tolerable minimums being -13 db and -6 db respectively. For convenience a -13 db level is specified as the minimum for both crosstalk and noise. A much greater ratio is desirable, of course, whenever it can be obtained.[22]

For military purposes, therefore, an ideal communications channel would have a bandwidth of approximately 4,000 cycles, a net loss of 3 db, and a high signal-to-crosstalk and signal-to-noise ratio. These communications channels and the other network elements must be combined in a meaningful pattern in accordance with their technical characteristics and the basic communications principles of reliability, security, speed, economy, and flexibility in order to provide a comprehensive and integrated communications system that will meet the needs of its users.[23] The result will be a complex of circuits interconnecting the numerous and

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[22]U.S. Department of the Army, TM 11-679, pp. 226-233.

[23]U.S. Department of the Army, TM 11-486-1, pp. 2-12 --2-14.

varied terminal instruments in use throughout the military area of operations.[24]

Circuits may be classified in several ways, depending on their intended purpose. A loop is a circuit that connects a terminal instrument such as a telephone or a teletypewriter to a switching facility. A trunk is a circuit connecting the switching facilities. If the circuit net loss of a trunk is low enough it may be further classified as a long-distance trunk, which can be switched to a loop or other trunk. Very noisy or high-loss trunks are designated as terminal trunks. These are restricted to direct service between the areas in which they terminate and are never switched to long-distance trunks or to other terminal trunks.[25] The class of switching facility served also influences the designation of trunk circuits. Tributary exchanges connect loops to each other or to a tributary trunk, which is a high-quality trunk suitable for transmission of long-distance calls. Tributary trunks connect the tributary exchange to local switching centers, which are in turn connected to secondary, primary, or zone switching centers by tandem trunks or direct trunks. Both tandem and

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[24] The terms circuit and channel are rather broad and are often used interchangeably. For the purposes of this work circuit will be used to designate one of the communications paths between two terminal instruments, two switching facilities, or a terminal instrument and a switching facility. Channel will be used to designate one of the communications paths between two points provided by a multichannel carrier system without reference to terminal instruments or switching facilities.

[25] U.S. Department of the Army, TM 11-486-3, p. 14-12.

direct trunks are long-distance quality trunks; a tandem trunk is connected to the next geographically located switching center while a direct trunk connects one switching center to another without regard for geographical location.[26] In any communications network beyond the most primitive more than one trunk will be required between switching centers. The total number of trunks interconnecting any two switching centers is called a trunk group.[27]

By their nature, all trunk circuits are common-user circuits, since any individual, organization, or communications facility with suitable terminal instruments can make use of them through the switching facilities provided for the purpose. Common-user circuits are the most economical in terms of men, money, and materials, and are the basis for military communications network planning. Due to the requirement for speed of communications, as in the case of certain command control circuits, or the existence of a large volume of traffic between two offices or commands, generally specified as 60 per cent of the average circuit capacity between the points to be served, sole-user circuits may be established.[28] A sole-user circuit is what its name implies; a circuit provided for the exclusive use of the parties concerned. This type of circuit is often referred to by other

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[26] *Ibid.*, pp. 14-1--14-4.

[27] U.S. Department of the Army, *Electrical Communications Systems Engineering: Traffic*, TM 11-486-2, (Washington: U.S. Government Printing Office, August 1956), p. 2-2.

[28] U.S. Department of the Army, TM 11-486-1, p. 2-4.

names such as point-to-point circuit, full-time allocated circuit, hot line, and so on.

The design of a military communications network thus far is primarily the function of the transmission and circuit engineer, and answers the question of what kind of communications will be provided and how they will be made available. The problem of how much communications is needed for a given situation and at what locations is the responsibility of the traffic engineer. Not all individuals, offices, or organizations will make use of the communications network at the same time or to the same degree. Some organizations, such as a medical unit, will have a large requirement to communicate with other organizations of the same type, a lesser requirement to communicate with higher headquarters, and scarcely any need or desire to contact anyone else. An army or a corps headquarters, on the other hand, requires communications with every subordinate, lateral, and higher headquarters. The more organizations that are based in a given geographical area, the greater will be the communications requirements to, from, and within the area. Based upon data concerning these factors gathered and analyzed by the traffic engineer, the size and location of switching centers, the routing of trunk groups, and the communications personnel requirements are computed.

The basic yardsticks for determining requirements are different for telephone and teletypewriter traffic engineering. In a telephone network experience has shown that

demands for service vary widely throughout the day, reaching a peak during the busy hour, a period of time defined as the continuous sixty-minute period of maximum demand for service. It may occur at different times of the day for different switching facilities or different trunk groups. The total number of calls during the busy hour multiplied by the average number of minutes that each call uses a circuit (holding time) gives the number of call-minutes.[29] One circuit can thus handle sixty call-minutes of traffic per hour. During the busy hour if ten calls with an average holding time of six minutes are expected one circuit might be able to handle the traffic without delay, but only if each call was placed just after the previous one, a remote possibility. If everyone called in at once at the start of the busy hour one caller would have to wait fifty-four minutes for service, an intolerable delay for most users. To prevent problems of this type from occurring more than one trunk must be provided, the total number depending on the standard of service to be provided the user. No-delay service assumes that only 1 to 3 per cent of the calls placed during the busy hour will be delayed due to all trunks busy (ATB) in the desired trunk group. Delay service requires a computation of the average holding time. With this information trunks are provided so that the delay in obtaining service during the busy hour will average 8, 30, or 120 seconds depending on the facilities available and the communication requirements.

[29] U.S. Department of the Army, TM 11-486-2, pp. 3-1, 3-2.

Individual calls may experience considerably greater delay than the average specified for this grade of service.[30]

In teletypewriter traffic engineering the basic yardstick is the total number of groups per day, where a group is defined as a word consisting of five characters and a space. Like telephone traffic, demands for service are not uniform throughout the day. The traffic capacity of a circuit is based upon its busy hour capacity, which in turn depends on the speed and type of operation (manual, semi-automatic, or automatic) of the teletypewriter terminal instruments.[31] Teletypewriter service in large networks such as that of the field army is generally provided by semi-automatic or automatic operation. The circuits required for this type of operation are essentially one-way circuits, since acknowledgement of receipt for each separate message is not required, and are referred to as <u>half-duplex</u> circuits. Two half-duplex circuits operating in each direction between two locations make one <u>full-duplex</u> circuit.[32] While two teletypewriter facilities in communication with each other require some form of two-way communication in order to provide reliable service, the amount of traffic flowing in one direction may be substantially greater than in the

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[30]*Ibid*., pp. 4-4--4-11.

[31]*Ibid*., pp. 10-1--10-6.

[32]*Ibid*., p. 10-3.
U.S. Department of the Army, *Strategic Army Communication (STARCOM) Operating Procedures*, TM 11-490-1, (Washington: U.S. Government Printing Office, December 1960), p. 5-17.

other. As a consequence more circuits may be required in one direction. For small tactical switched-circuit teletypewriter networks the number of trunks necessary is computed in the same manner as for telephone trunks.[33]

The points at which trunks will terminate are also a matter for determination by the traffic engineer. While technically possible to complete a call from one telephone through a series of switching centers to a distant telephone, the human factor inherent in manual switching makes this procedure difficult. Wrong numbers, cutoffs, and the average holding time increase rapidly with the number of switching centers involved, and the speed of service to the user decreases accordingly. It is desirable that the number of intermediate switches be limited to one or two at the most. Trunk groups must be provided between switching centers regardless of their location when a switched route with less than three switches is not available, when the importance of the traffic warrants, or when the traffic between two centers is large enough to justify a direct trunk group.[34]

The traffic engineer, therefore, is the man who provides the answers to how much communications will be provided where. Two other decisions must be made; who will install, operate, and maintain the network or its components, and when these tasks will be accomplished.

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[33]U.S. Department of the Army, TM 11-486-2, p. 10-7 --10-9.

[34]U.S. Department of the Army, TM 11-486-1, pp. 7-19 --7-22.

In many cases the answers to these questions are determined for the commander. The type of unit to accomplish a designated task is often dependent on the type and number of signal units available and the characteristics of their equipment. The time element is frequently inherent in the mission of the command, particularly in a tactical situation.

There is one aspect of timeliness, however, which is unique to signal operations, originating in the fact that circuits vary greatly in importance. A sole-user circuit connecting the field army tactical operations center (FATOC) to the corps tactical operations center is obviously of much greater importance than one of several common-user tandem trunk circuits between rear area signal centers. The measure of this importance is called the circuit priority, and its determination is a matter of command responsibility. When determined it directs the signal officer to carry out the installation or restoral of circuits in a given order. Present doctrine offers general guidance in assigning priorities. First priority is given to combat command and control circuits, such as the sole-user circuit connecting tactical operations centers mentioned above. Second priority goes to intelligence and nuclear control circuits. Third priority is assigned to fire control and combat support command control circuits. Fourth priority circuits are direct circuits to logistical support elements. All other circuits are assigned fifth priority. Recommended practice limits the assignment of priorities to these general classes

in order to provide a small amount of latitude to the elements responsible for installing, operating, and controlling the communications system.[35]

Taken together, the answers to who, what, when, where, how, and how much provide an integrated communications system that will accept a message in the originator's desired format and deliver it to the recipient in compliance with the originator's statement of urgency, specified format, and without loss of clarity. Because demands vary in kind and number the system must be flexible, and because resources are limited it must be economical. Above all it must be reliable--for without communications, command of the modern army is impossible.

[35] U.S. Department of the Army, Tactical Signal Communication Systems, Army, Corps, and Division, FM 11-21, (Washington: U.S. Government Printing Office, November 1961), p. 26.

CHAPTER III

THE FIELD ARMY COMMUNICATIONS SYSTEM--
REQUIREMENTS AND RESOURCES

At the close of World War II and throughout the Korean conflict the concept of communications support throughout the combat zone was almost exclusively command-oriented. Each army unit was provided with the necessary signal personnel and equipment to maintain communications to the next subordinate headquarters in normal tactical situations.[1] Under this concept communications were provided from the higher command post to the next subordinate unit's command post, with circuits and systems installed over multiple routes wherever possible. As the fortunes of battle changed an organization would move forward or back, relocating its command post to previously selected positions. An imaginary line connecting the command post locations, actual and proposed, of an organization was called the <u>axis of signal communications</u>.[2]

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[1]U.S. Department of the Army, <u>Staff Officers Field Manual: Organization, Technical and Logistical Data</u>, FM 101-10, (Washington: U.S. Government Printing Office, July 1953), p. 176. (FOR OFFICIAL USE ONLY).

[2]U.S. Department of the Army, <u>Signal Communications</u>, FM 24-5, (Washington: U.S. Government Printing Office, August 1950), pp. 141-143.
A communications system limited to linking headquarters echelons in tandem is called a <u>single-axis system</u>.

By 1954, with the use of atomic weapons on the battlefield of the future becoming more and more probable, the vulnerability of a single-axis system was apparent. In October of that year the U.S. Army Chief Signal Officer established a Communications System Ad Hoc Group to implement Army Field Forces concepts for the future army. The group's report in February 1955 included the following statement:

> Two-sided atomic warfare has also pointed up the requirement for a grid or area communication system at Corps and Field Army Level. The concept of a flexible organizational structure with units dispersed over a large area in the face of enemy atomic warfare capability necessitates a communication system capable of providing rapid, reliable communications to widely separated or dispersed units; a capability of absorbing the impact of enemy atomic attack, and of quick reaction to meet changes in operational plans in the task organization. In order to provide these increased capabilities, the signal company of the division is replaced, under the new concept, by a signal battalion. The present single-axis communications system is replaced by the concept of a grid-type communications system, and at the higher echelons of the Army in the field by a plan for a similar grid or area system.[3]

The area communications system concept was tested during Exercise Sage Brush, which took place in Louisiana in the fall of 1955. The basic elements of the new area

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[3]Letter, Office of the Chief Signal Officer to U.S. Army Electronic Proving Ground, 24 February 1955, Subject: "Communications System Ad Hoc Group" and report of Ad Hoc Signal Corps System Test--AEPG-4 Prototype Communications System 1955-1960, 7 February 1955, contained in U.S. Army Electronic Proving Ground, "Annex B," to Prototype Area Communications System, USAEPG-Sig-960-16, ("Final Report - Phase I Project USAEPG-4"; Fort Huachuca, Arizona: November 1957), pp. 3, 7-8. (File No. C-18127.113-A, Fort Leavenworth, Kansas Library). (CONFIDENTIAL MODIFIED HANDLING AUTHORIZED).

system were twenty-four army area communication centers linked with newly-developed twelve-channel telephone carrier systems (AN/TCC-7) and four-channel teletypewriter carrier systems (AN/TCC-20) operating over improved spiral-four cable and new radio relay equipment (AN/TRC-24). Extensions from these area communications centers were provided by four-channel telephone carrier systems (AN/TCC-3) using the old reliable radio relay set of World War II, the AN/TRC-1, or the new spiral-four cable which had been specifically designed to be technically compatible with either the four- or twelve-channel telephone carrier equipments. When required, twelve-channel systems were also used for extensions. For the first time provision was made for speedy routing or rerouting of circuits by the use of a tactical patch panel, a communications device permitting one channel to be quickly connected to another by the insertion of a cord equipped with plugs at both ends into the appropriate jacks. Long in use in fixed communications facilities, the patch panel provided tactical communicators with a flexibility previously unknown in field communications. Hastily fabricated, this equipment was designated a Communication Control Set (AN/MSC-23) and proved invaluable to the successful operation of the system in spite of frequent breakdowns caused by the fragile nature of the patching equipment used. The AN/MSC-23 was not the only hastily-improvised piece of equipment used during Exercise Sage Brush. Much of the communications equipment was so new

that it received an extensive field test for the first time during the exercise.[4]

In spite of problems encountered during the test due to such factors as new equipment, untrained personnel, and shortages of essential signal units and equipment, the area communications system functioned well. It proved to have the necessary flexibility and ability to survive that was required under the concept of atomic warfare tested in Exercise Sage Brush.[5]

As formally adopted by the U.S. Army, the area communications system comprised from eighteen to twenty-four area signal centers dispersed throughout the field army area. Headquarters signal centers at army main, army alternate, army rear, army tactical command post, and at corps main, advance, and rear headquarters were provided.[6]

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[4]U.S. Fourth Army, "Annex E, Communications and Electronics," Report of Army Tests: Exercise Sage Brush, (Fort Sam Houston, Texas: 18 February 1956), Vol. II Part II, pp. E-2-11, E-3-2, E-3-10, E-3-11. (File No. N-18120.12, Fort Leavenworth, Kansas Library).

[5]*Ibid.*, pp. E-2-11--E-2-13.

[6]The term signal center was chosen in place of communications center to show the increased communications responsibilities of the signal center. Communications center is restricted to a communications facility which provides for the receipt and delivery of record communications only.

(U.S. Department of the Army, Tactical Signal Communication Systems, Army, Corps, and Division. FM 11-21, [Washington: U.S. Government Printing Office, November 1961], pp. 5, 6.)

(U.S. Department of the Army, "Communications/Signal Center," "Message Center," and "Signal Center," Dictionary of United States Army Terms, AR 320-5, [Washington: U.S. Government Printing Office, April 1965], pp. 104,

Each area signal center was installed and operated by a combat area signal company. It provided up to eight multi-channel telephone carrier systems to link the signal center with adjacent centers and major subordinate headquarters as required, a radio-wire integration station to connect mobile tactical FM radio stations into the army area signal system, wire extension links to units served by the area signal centers, telephone and teletypewriter switchboards, patching facilities to interconnect the channels of the carrier systems as required, and message center service including cryptographic support. To obtain the last-named service using units were required to pick up and deliver their own messages to the signal center. Four combat area signal companies made up a combat area signal battalion, which was attached to the army area signal group. Army command signal centers were provided by the army signal battalion. Command control systems for the corps were installed and operated by its organic corps signal battalion, which also provided command signal centers at the echelons of corps headquarters.[7] In operation it was envisioned that the signal centers assigned to one battalion would be dispersed linearly from front to rear in the field army area. Each would have its

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[7]U.S. Department of the Army, <u>Combat Area Signal Battalion, Army</u>, FM 11-86, (Washington: U.S. Government Printing Office, December 1958), pp. 5, 24-26.

U.S. Department of the Army, <u>Army Signal Battalion</u>, FM 11-95, (Washington: U.S. Government Printing Office, April 1960), p. 7.

U.S. Department of the Army, <u>Corps Signal Battalion</u>, FM 11-92, (Washington: U.S. Government Printing Office, November 1959), pp. 4-6.

own area of responsibility, within which it would provide communications services to all units requiring access to the army area system. The signal center nearest to a division was responsible for establishing a multichannel system to that division. Signal centers designated by the army signal officer also provided multichannel links to signal centers of adjacent armies.[8]

In establishing the army area communications system in a new area of operations one of the major tasks of the army signal officer is to determine the number and location of signal centers to be installed. Given flat terrain without obstacles and a uniform dispersal of using units the problem would be relatively simple, but terrain is seldom flat, obstacles exist, and using units are not arbitrarily situated on a map. Combat support units assigned to a field army are normally located near the division rear boundary where they can best support the combat divisions. Logistical units tend to locate near railroads, major highways, or airfields in order to simplify transportation problems. Civil affairs units locate near the local seat of government with which they are associated. Terrain and the enemy situation also play an important role in the establishment of signal centers. Multichannel radio relay links of the field army are still dependent on line-of-sight paths between stations. Rear area security problems may make it impossible to establish repeater stations to extend these

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[8]U.S. Department of the Army, FM 11-86, pp. 5-6.

links over difficult terrain even when technically feasible to do so, and may also influence the dispersal of the using units to a certain extent.

The number of using units as well as their location adds to the magnitude of the problem. A type field army of the 1965-1970 period designed for employment in a large-landmass environment contains, in addition to the echelons of army headquarters, 3 corps headquarters, a field army support command (FASCOM) headquarters, 14 divisions, 3 corps artillery headquarters, 20 separate brigades, 67 regimental or group headquarters, 279 separate battalions, 499 separate companies and 446 separate platoons or detachments, all scattered over an area that may be 320 kilometers wide and 300 kilometers deep.[9]

All of these organizations require communications if they are to accomplish their mission. While many of the smaller units of company and detachment size will be colocated with the battalion or group headquarters to which attached and will be provided communications by their parent unit, the total number of organizations at battalion level and above, 406, is still an impressive figure. With the exception of those units attached to a division and employed within the divisional area of responsibility the communications

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[9]U.S. Army Combat Developments Command Combined Arms Agency, CD Study, "Field Army Requirements for Tactical Communications (TACOM)(U)," (Fort Leavenworth, Kansas: November 1964), Vol. II, p. 3-10. (File No. C-18968.29-B.1-3, Fort Leavenworth, Kansas Library). (CONFIDENTIAL). See Table 1.

TABLE 1

FORCE STRUCTURE OF A LARGE-LAND-MASS TYPE FIELD ARMY[a]

Branch or Function	Army Headquarters	Corps Headquarters	Corps Artillery	Divisions	Separate Brigades	Regiments/Groups	Separate Battalions	Separate Companies	Separate Plat/ Detachment
Headquarters	1	4[b]			4				
Divisions				14					
Separate (Maneuver) Brigade Base					6				
Infantry							14		
Armor						4	6		
Field Artillery			3			12	64	6	
Air Defense Artillery					1	5	28		
Military Intelligence							2	1	23
Army Security Agency						1	3	16	
Aviation						4	10	50	
Chemical						1	4	16	17
Engineer					4	9	35	51	21
Medical					1	4	40	42	191
Military Police					1	2	7	13	7
Ordnance					1	3	6	33	1
Quartermaster							2	19	2
Signal					1	2	11	6	51

TABLE 1--Continued

	Army Headquarters	Corps Headquarters	Corps Artillery	Divisions	Separate Brigades	Regiments/Groups	Separate Battalions	Separate Companies	Separate Plat/ Detachment
Transportation					1	2[c]	5	79	
Supply, Maintenance and Services						17[d]	46	133	2
Adjutant General							4	26	45
Civil Affairs						1		5	
Finance									14
Historical									17
Judge Advocate General									41
Psychological Operations							1	3	7
Public Information									7
Special Forces							3		
Total	1	4	3	14	20	67	297	499	446

[a]Extracted from U.S. Army Command and General Staff College, Organizational Data for the Army in the Field, RB 101-1, (Fort Leavenworth, Kansas, 2 March 1966), pp. 15-35.

[b]Includes the field army support command headquarters (FASCOM).

[c]Includes one transportation center (movements control).

[d]Includes one inventory control center (ICC).

for the day-to-day operations of these units must be provided by the army area communications system.

The number and location of signal centers to be installed is therefore a direct function of the requirements of the using units, and is basically a problem in traffic engineering. In a commercial communications network the users are relatively stable and their circuit requirements are easily computed by the application of probability theory, using data gathered from an analysis of how many calls are placed from one location to another. This type of analysis does not lend itself readily to the problems of the mobile, ever-changing military community, particularly within the combat zone. Lacking long experience in providing communications for a stable community in a known geographical area, the best alternative method of compiling circuit requirements is to go to the users themselves to determine with whom they need to communicate, when, and for how much of the time.[10] Although efforts had been made from time to time to provide a type listing of circuit requirements within the field army area, what little was available was felt to be of doubtful value, and the U.S. Army Electronic Proving Ground declined to attempt a detailed computation of circuit needs when that organization published a staff

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[10]U.S. Department of the Army, Electrical Communications Systems Engineering: Traffic, TM 11-486-2, (Washington: U.S. Government Printing Office, August 1956), p. 4-1.

study on system control of the Pentomic Army area communications system in January 1958.[11]

The task of developing a type circuit listing fell to the U.S. Army Combat Developments Command, which began to do so in late 1963 by assuming a type field army of two corps and eight divisions, deploying the army elements in a tactical situation, and requesting information concerning their communications demands on the common signal service (the army area communications system) from agencies representing the viewpoint of the using units. Users were requested to furnish information about the location from which calls would be placed, the subscriber placing the call, the location to be called, and the frequency and importance of the call.[12] For the purposes of the study the importance was to be specified as urgent, a call that must be placed within five minutes, or routine, a call that could be placed with a delay of up to fifteen minutes or which could be placed later without any problem. Frequency was specified as the number of calls placed during a given time period: daily, less than five and more than zero calls per day; frequently, less than one per hour and more than five calls per day; constantly, one or more calls per

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[11] U.S. Army Electronic Proving Ground, Staff Study on System Control of the Army Area Communication System of the Pentomic Army, USAEPG SIG 940-26, (Fort Huachuca, Arizona: January 1958). (File No. N-18127.105-A, Fort Leavenworth, Kansas Library). See especially "Annex I," p. 2.

[12] Subscriber, a term borrowed from commercial practice, is used to designate an individual or an organization to which telephone or teletypewriter service is extended.

hour throughout the day; weekly, less than seven and more than zero calls per week; and infrequently, less than one call per week. Using traffic engineering techniques the study compiled maximum demands on the army area communications system for 214 different types of field army units.[13]

An analysis of these demands showed that user requirements varied widely at the same echelon of command. An engineer combat battalion required only 0.02 teletypewriter and 1.346 telephone channels to accomplish its mission, where a medical battalion required 0.34 teletypewriter and 2.04 telephone channels at its forward headquarters and 0.02 teletypewriter and 1.04 telephone channels at its rear headquarters.[14] The channel requirements developed in the study are highly detailed and would have to be revised based upon the actual situation before use. It is possible, however, to provide general guidance concerning circuit requirements for planning purposes, based upon this or other data, which would be sufficient to permit initial installation of the communications system. Refinements can be made at any time as additional data becomes available. One example of this type of guidance is found in FM 11-21, where the tributary trunk planning factors of six telephone and two teletypewriter circuits to each brigade, three telephone and one teletypewriter circuit to each separate battalion, etc., are

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[13] U.S. Army Combat Developments Command Combined Arms Agency, CD Study . . . TACOM, Vol. II, pp. 1-1, 1-5, 1-12, 1-19, 1-23, 1-25 and Figs. 1.3, 1.15, and 1.16.

[14] Ibid., Vol. III, pp. 22, 141.

given.[15] An estimate of the tributary trunk requirements for a large-land-mass field army using the guidance of FM 11-21 yields a figure of 1,400 telephone and 500 teletypewriter tributary trunks. With 18 signal centers deployed the average number of tributary trunks per center amounts to 78 telephone and 28 teletypewriter circuits. Assuming one local loop per separate company, one area signal center would, on the average, be responsible for approximately 27 loops, and would require an additional 25 loops or so for miscellaneous activities such as traffic control points, shower points, etc., which might be expected to be in the area.[16] A figure of 19 long-distance trunks to serve these circuits is obtained by applying the planning formula of FM 11-21. The total common-user circuits for the field army would then amount to approximately 2,700. Teletypewriter trunk circuit requirements can be roughly calculated based upon the traffic capacity of the machines available and their mode of operation, but the number of teletypewriter trunks needed is more dependent on the type and number of organizations located in the signal center area of responsibility than are telephone trunks. Not all organizations have or require a teletypewriter capability. Meaningful computations are extremely difficult to make until the actual deployment of field army organizations is known.[17]

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[15]U.S. Department of the Army, FM 11-21, pp. 24-25.

[16]*Ibid.*, pp. 24-25, 70-71. [17]*Ibid.*

The requirement for sole-user circuits is an additional heavy burden on the area system. Applying the type force structure of RB 101-1 to the guidance of FM 11-21 results in a figure of 101 telephone and 30 teletypewriter sole-user circuits.[18] More up-to-date guidance is contained in the TACOM study, which lists approximately 17 facsimile, 266 teletypewriter, 319 telephone, and 110 automatic data sole-user circuits for a three-corps field army, a considerable increase in requirements from those of 1961 when FM 11-21 was published.[19]

Based upon the assumed tactical situation, and with all circuit requirements carefully computed, the TACOM study concluded that channel requirements between adjacent signal centers might be as high as 84.4 telephone and 7.8 teletypewriter channels. This is the equivalent of over seven twelve-channel carrier systems. These figures did not take into account the provision of additional channels to permit emergency rerouting of circuits required by the destruction of a major facility, or to permit restoration of circuits within the system caused by equipment failures or other communications problems, requirements estimated to be

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[18] Ibid.
The Command and General Staff College, RB 101-1, pp. 15-35.

[19] U.S. Army Combat Developments Command Combined Arms Agency, CD Study . . . TACOM, Vol. II, pp. 3-10, 3-11, Fig. 3.5.

approximately two-thirds of the known channel requirements.[20]

Adding these extra channel requirements to the known demands gives a figure of approximately 140 channels required between two signal centers. These are by no means the complete channel terminations at a signal center. Each center maintains communications with each adjacent center by lateral and front-to-rear multichannel systems. In the "worst case" shown in the TACOM assumed system deployment, one signal center terminates approximately 232 channels, or the equivalent of nineteen twelve-channel carrier systems, almost all of which will be operating over radio relay links due to the necessity for rapid installation and frequent relocation of the communications system elements.[21] When two or three additional multichannel radio relay systems to support major users in the signal center's area of responsibility are added the total number of systems terminating in one location becomes twenty-two or twenty-three.

Frequency allocation becomes a problem of almost unmanageable proportions in such a situation. The planners of the 1930's were faced with such a problem, but the hoped-for technological breakthrough occurred, permitting the extensive use of radio communications in World War II.[22]

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[20] Ibid., Vol. II, p. 3-37 and Fig. 3.7.

[21] Area signal center "R," Ibid.

[22] See above, pp. 9-10.

Although the limited frequency spectrum available to the army in the 1930's has been expanded far beyond what was thought possible thirty years ago, frequency use has increased at an even greater rate within the field army area. Fortunately, new technological developments, while not eliminating the problem, may make it possible to continue to enjoy the benefits of radio relay in the tactical communications system. Chief of these is the use of pulse code modulated (PCM) carrier equipment, which makes ninety-six channel carrier systems possible.[23] An additional advantage is the fact that the transmitted signal, composed of a series of electrical pulses, is much less susceptible to error than a signal composed of various frequencies. It can be regenerated whenever distortion appears by techniques similar to those used in telegraph systems of the nineteenth century. The result is a received signal virtually free from transmission error and the effects of circuit noise.[24] Tropospheric radio and satellite communications systems are also of great importance. Their use extends the range of the new multichannel carrier systems far beyond the line-of-sight path required for conventional radio relay employment. Both

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[23]Pulse code modulation is a technique of measuring an electrical signal from a terminal instrument at regular time intervals and encoding the signal amplitude at that moment as a series of binary pulses which are then transmitted to the distant terminal. (U.S. Department of the Army, *Electrical Communication Systems Engineering: Transmission and Circuit Layout*, TM 11-486-3, [Washington: U.S. Government Printing Office, December 1956], pp. 4-10--4-11.)

[24]*Ibid*., p. 4-11.

PCM techniques and long range multichannel radio systems reduce the number of radio emitters within the field army area, one by providing a greater channel capacity per transmitter, the other by eliminating the requirement to install intermediate radio relay repeaters.

After analyzing the future field army communications requirements, new developments in communications technology, and other factors, the TACOM study group recommended that field army communications be provided by a "command plus area" system. Under this concept the area system with its twenty-four signal centers would continue to furnish communications for the bulk of the field army units. The corps would retain its signal battalion to establish command communications systems to its major subordinate headquarters and for its corps artillery.[25] The field army would be given the capability to establish command systems to its major tactical units such as the corps. The type signal organization to install and operate the army network would be headed by an army signal brigade with two subordinate signal group headquarters. The operating units would consist of six area signal battalions with four companies each; an army command operations battalion to provide telephone, teletypewriter, and motor messenger service for the echelons of army headquarters; and an army command radio and cable battalion which would install and operate the

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[25] U.S. Army Combat Development Command, CD Study . . . TACOM, Vol. II, p. 2-53.

army command communication links to subordinate elements of the field army and between the army headquarters echelons.[26]

The area signal center, installed by the area signal company, is the basic operating element of the field army communications system. While its functions are generally similar to those of the 1955-era signal center, the types of equipment to be used differ greatly in many cases, and the communications capabilities of the center have been increased accordingly. An organization chart of the army area signal company is shown in Figure 2. The company headquarters provides the necessary command supervision over company activities. The operations platoon furnishes telephone and teletypewriter switching, radio-wire integration, teletypewriter, cryptographic, facsimile, and message center service for the signal center area of responsibility. The radio relay access platoon provides the multichannel carrier systems to connect the operating facilities at the signal center to adjacent signal centers, with a total capability of terminating 288 PCM channels. A type installation of this platoon employs ninety-six-channel systems for the front-to-rear links and forty-eight-channel links

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[26]<u>Ibid</u>., pp. 3-53--3-89; 4-33--4-56. See Fig. 1.

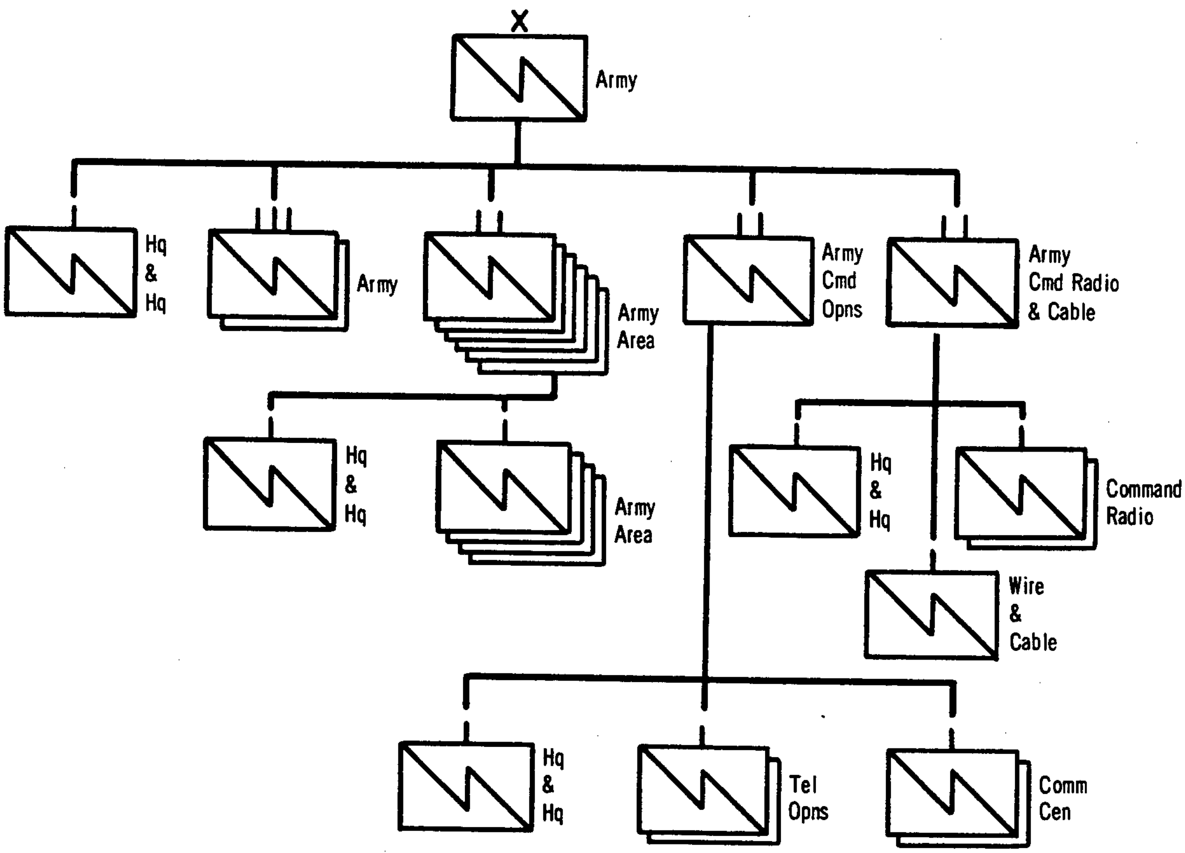
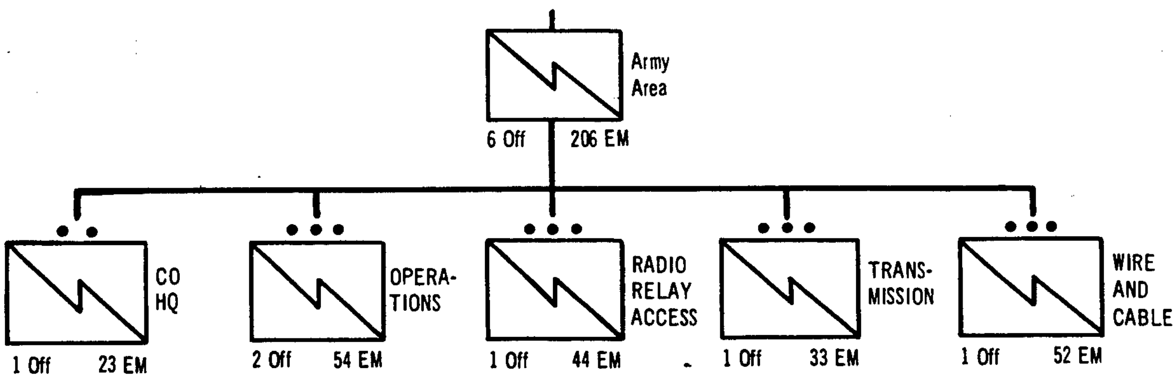


Figure 1. Field Army Signal Organizations[a]

[a]U.S. Army Combat Developments Command, <u>CD Study</u> . . . <u>TACOM</u>, Vol II, pp. 3-57, 3-63, 3-70, 3-79



AN/VRC-46	1	AN/MTC-1	1	AN/TRC-111	2	AN/VRC-46	5	AN/VRC-46	1
AN/MSC-32	1	SB-22	2	AN/TCC-60	2	AN/TRC-111	4		
		TA-312	16	AN/TCC-63	1	AN/TCC-63	4		
		AN/VRC-46	1	AN/TRC-118	4	KG-5	16		
		AN/VRC-49	1	AN/TRC-119	2	SB-675	1		
		AN/GRA-39	1	KG-5	16				
		AN/GRC-108	1	SB-675	1				
		AN/GRA-74	1	AN/VRC-46	3				
		AN/MSC-29	1						
		AN/GSQ-80	1						
		AN/MGC-19	1						
		KW-7	7						
		KL-7	2						
		KL-15	2						
		AN/GXC-5	1						

Figure 2. Army Area Signal Company[a]

[a]U.S. Army Combat Developments Command, CD study . . . TACOM, Vol. II, p. 3-68

deployed laterally.[27] The transmission platoon provides up to four forty-eight or ninety-six-channel extension systems from the signal center to major users requiring communications support from the signal center. The wire and cable platoon is responsible for installing wire lines where feasible within the signal center area of responsibility.[28]

Long-distance army command circuits are operated by the command radio and cable battalion. The major operating elements are the battalion's two command radio companies. An organization chart is shown in Figure 3. The headquarters section provides command supervision over the company's activities. The radio platoon operates the radio teletypewriter equipment for the various army command nets. The radio relay platoon has a capability of terminating up to eight twenty-four-channel PCM systems over radio relay equipment. The tropo platoon has the same channel termination capability using tropospheric scatter radio systems.[29]

The field army communications system of the future will be a combination of an area-oriented and a command-

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[27]U.S. Army Combat Developments Command, CD Study . . . TACOM, Vol. II, pp. 3-68, 3-69.

U.S. Army Electronics Command, The Army Area Communications System: Description of Subsystems; Principal Characteristics of Assemblages, (Fort Monmouth, N.J.: October 1966), pp. 2-1, 3-2. (File No. N-17506.48, Fort Leavenworth, Kansas Library).

[28]U.S. Army Combat Developments Command, CD Study . . . TACOM, Vol. II, p. 3-69.

[29]*Ibid.*, pp. 3-86--3-87.

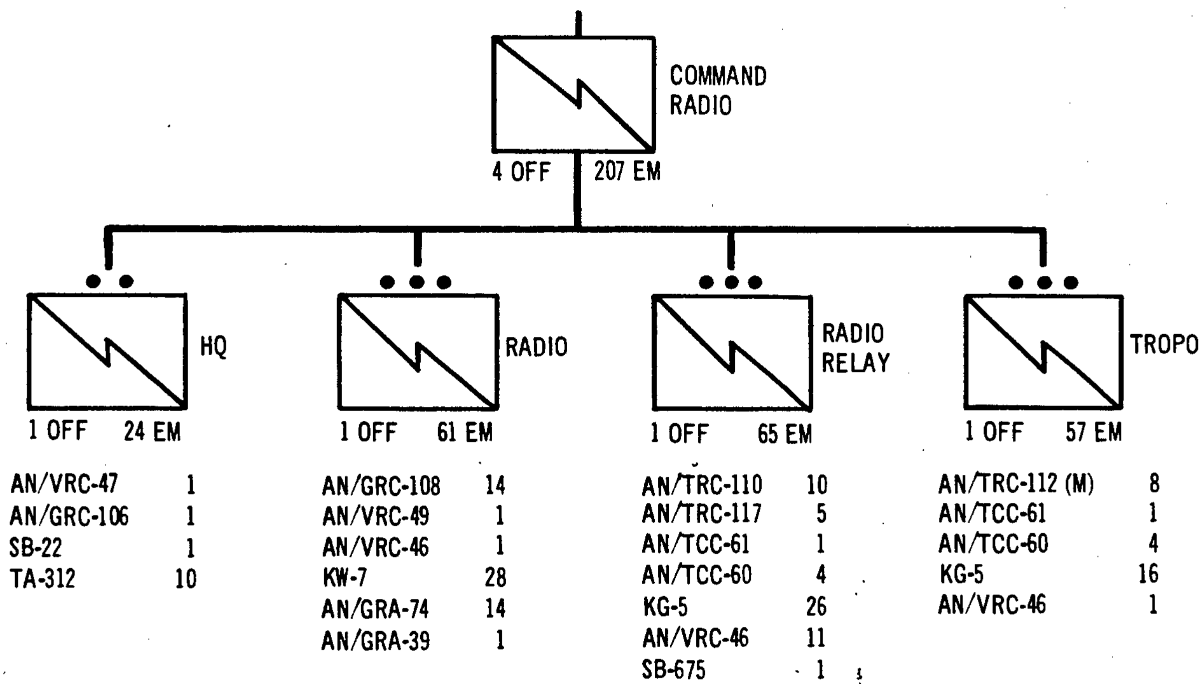

Figure 3. Army Command Radio Signal Company[a]

[a]U.S. Army Combat Developments Command, CD Study . . . TACOM, Vol. II, p. 3-86

oriented system, providing multichannel communications links in quantity to meet the command, administrative, and logistic requirements of the army. At the same time it will retain and employ multichannel links to provide quick reaction to developing situations and insure positive command control of the tactical forces. It will accommodate the thousands of circuits required by the field army and its hundreds of subordinate units. To insure an integrated and responsive communications system the signal operating elements must have clear and positive direction. The field army communications network must function as a single entity with one purpose--to "get the message through."

CHAPTER IV

COMMUNICATIONS SYSTEMS CONTROL--
U.S. ARMY DOCTRINE AND METHODS

The technical problem of organizing and controlling the field army communications system is difficult and complicated. It is not surprising that several different solutions have been developed and applied to this aspect of signal operations by the various headquarters requiring large-scale communications support to meet the control requirements of their communications networks. Not the least of the difficulties encountered is the question of what is involved in communications systems control and by what individual, staff section, or agency control will be exercised.

During World War II and the Korean War control of the communication network for an army organization was primarily the responsibility of the signal officer at that echelon. With the advent of the field army area communications system in 1955 it was apparent that the problem of organizing and controlling the communications network would be vastly more complicated and difficult than was the case with the single-axis system previously in use.

The army communications concepts tested in 1955 by Exercise Sage Brush had included the provision of an operational element in the army area signal group to relieve the army signal officer and his staff from the necessity of personally directing the details of system employment. The planners who had drafted the initial communications program apparently felt that the signal officer should be limited to planning and the preparation of mission-type orders for the operating elements. The responsibility for the operational aspects of the communications system should be restored to the units which installed and operated the system.[1] The results of Exercise Sage Brush confirmed the necessity for a systems control element of the type provided and tested during that exercise.[2] The various methods and techniques which have been developed for communications systems control operations are discussed in the following pages.

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[1] U.S. Army Electronic Proving Ground, "Annex C, General Concepts of Control of Army Area Communications Systems," Staff Study on Systems Control of the Army Area Communication System of the Pentomic Army (U), USAEPG SIG 940-26, (Fort Huachuca, Arizona: January 1958), p. 2. (File No. N-17506.48, Fort Leavenworth, Kansas Library).

U.S. Army Electronic Proving Ground, "Appendix H-3, Reports of Field Exercises and Maneuvers Pertaining to Communication Systems Control," Development of the Communications System and Equipment Integration Plan for the Field Army, 1962-1965 (U), SIG CCD 58-4, (Draft Report; Fort Huachuca, Arizona: October 1960), Vol. IV, H-3 p. 4. (File No. N-18538.12-D, Fort Leavenworth, Kansas Library).

[2] U.S. Fourth Army, "Annex E, Communications and Electronics," Report of Army Tests Exercise Sage Brush, (Fort Sam Houston, Texas: 18 February 1956), Vol. II, Part II, pp. E-2-19, E-2-23. (File No. U-18120.12-D, Fort Leavenworth, Kansas Library).

U.S. Army Electronic Proving Ground, Staff Study on System Control of the Army Area Communication System of the Pentomic Army, 1958

The task of determining the preliminary concepts and techniques of systems control for use by the army area signal group was assigned to the U.S. Army Electronic Proving Ground, which produced the initial review of the field army communications control requirements in their staff study of January 1958. This document, portions of which were later to be incorporated into FM 11-21 as field army communications doctrine, proposed that the systems control and information section of the army area signal group be assigned the mission to:

> coordinate, direct and supervise the installation, operation and maintenance of the army area communication system and its components in providing the detailed engineering and implementation of the army communication system in support of the field army, including long-line requirements and tie-in to the tactical units, administration and support elements.[3]

The study recommended that the system control section perform the following functions:

1. Direction and coordination of system installation and operations.
2. Engineering and direction of routing and rerouting circuits.
3. Traffic analysis and determination of general communication requirements.
4. Assuring the provision of circuits in the area system to meet user requirements.
5. Assignment of circuits to meet special requirements as directed by the signal officer.
6. Inspection of system facilities and operations.

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[3] U.S. Army Electronic Proving Ground, "Annex G, Systems and Circuit Control," USAEPG SIG 940-26, p. 1.

7. Technical assistance to subordinate signal units.[4]

The army signal group was provided the necessary equipment to terminate sole-user telephone and teletypewriter control circuits. These were established between the group systems control section and subordinate signal battalion operations and intelligence sections. Tactical FM voice radio equipment was also furnished to the control group for use in establishing the army area communications network before the multichannel systems became operational, with the intent that this radio net would provide a back-up control means in the event of system failure.[5] The FM radio equipment was replaced with AM voice and radio-teletypewriter equipment in 1963.[6]

In order to control systems and circuits they must first be identified as discrete parts of the communications network. Two ways in which this can be done are: (1) by defining the system or circuit in terms of the terminal locations, which in turn requires that terminals be individually identified, or (2) by assigning an arbitrary number, word, or symbol to each system or circuit to be established.

The Electronic Proving Ground study group chose the first method to designate systems. For this purpose they

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[4] Ibid., pp. 1-2.

[5] U.S. Department of the Army, Combat Area Signal Battalion, Army, FM 11-86, (Washington: U.S. Government Printing Office, December 1958), p. 8.

[6] U.S. Department of the Army, "Change 1 (23 July 1963)," to FM 11-86, p. 2.

first identified terminals, which were area signal centers, command signal centers, or using units, by assigning to them a signal center and unit designator. This is a combination of the telephone directory name (unit code) which is assigned to each unit equipped with a switchboard and an arbitrary exchange number taken from number blocks allotted to the various levels of command such as division, corps, and army.[7] A system is identified by a combination of the signal center and unit designators of the system terminals. A multichannel system connecting the field army main command post (MONARCH 700) with a subordinate corps headquarters (DANGER 250) would be designated MON (the first syllable of the telephone directory name) 700-DAN 250. The first signal center and unit designator appearing in the system designator (in this case MON 700) shows the system terminal responsible for coordinating system installation, operation, and adjustment. Where two or more systems are established between the same locations a letter suffix is added to the first component of the basic designator: MON 700-DAN 250 is the first system established; MON 700B-DAN 250 the second system. If the first syllable of the exchange name is the same for both system terminals it is given only once; for example, a system between the two signal centers MONARCH 711 and MONARCH 712 is designated MON 711-712.[8]

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[7]U.S. Army Electronic Proving Ground, "Annex D, Field Army Signal Center and Unit Designations," USAEPG SIG 940-26, pp. 1-2.

[8]U.S. Army Electronic Proving Ground, "Annex E, System and Circuit Designators," USAEPG SIG 940-26, p. 1.

The second method was chosen to designate circuits. A block of circuit numbers was allotted to the echelons of command to identify circuits initiated and controlled by that echelon. The field army was given the block of numbers from 3000 to 7999. Where necessary to avoid confusion, as in the case of a circuit between two adjacent armies, the first syllable of the exchange name assigned to the controlling headquarters was prefixed to the circuit number.[9]

Assigning a circuit number is only the first step in control. Additional information such as the location of the terminal instruments and the specific channels and systems over which the circuit passes is required. The study group recommended the use of circuit order and record cards for this purpose. These cards listed the circuit number, date and order establishing the circuit, its terminals, and the systems and channels over which the circuit is routed. A card was to be maintained for each circuit in operation.[10]

Other records which the system control and information center was expected to maintain were traffic diagrams,

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[9] Ibid., p. 2.

[10] U.S. Army Electronic Proving Ground, "Appendix 2, Circuit Record Card, to Annex E," USAEPG SIG 940-26, p. 1. The circuit listed in the above reference is apparently a trunk group rather than a single circuit.

unit locator information, and the signal situation map.[11]

U.S. Army Electronic Proving Ground, Development of the Communications System and Equipment Integration Plan for the Field Army 1962-1965, 1960

Although the study group considered their paper "an adequate guide for preparation of a doctrinal manual and school instruction,"[12] it was a sketchy outline at best. In 1960 the U.S. Army Electronic Proving Ground was again directed to examine the problem of the 1962-1965 field army communications system, including systems and control procedures.[13] The new committee convened for this purpose found that the army area signal network systems control element "failed to provide effective signal support. . . . due to overlapping and duplication of responsibilities and effort among the agencies appointed to carry out control functions."[14]

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[11]U.S. Army Electronic Proving Ground, "Annex G, Systems and Circuit Control," USAEPG SIG 940-26, p. 2.

The traffic diagram is an abstract chart which shows trunk circuits between switchboards and is primarily used by telephone operators to route calls.

The unit locator records provide the exact location of units and their point of connection into the army area communications system.

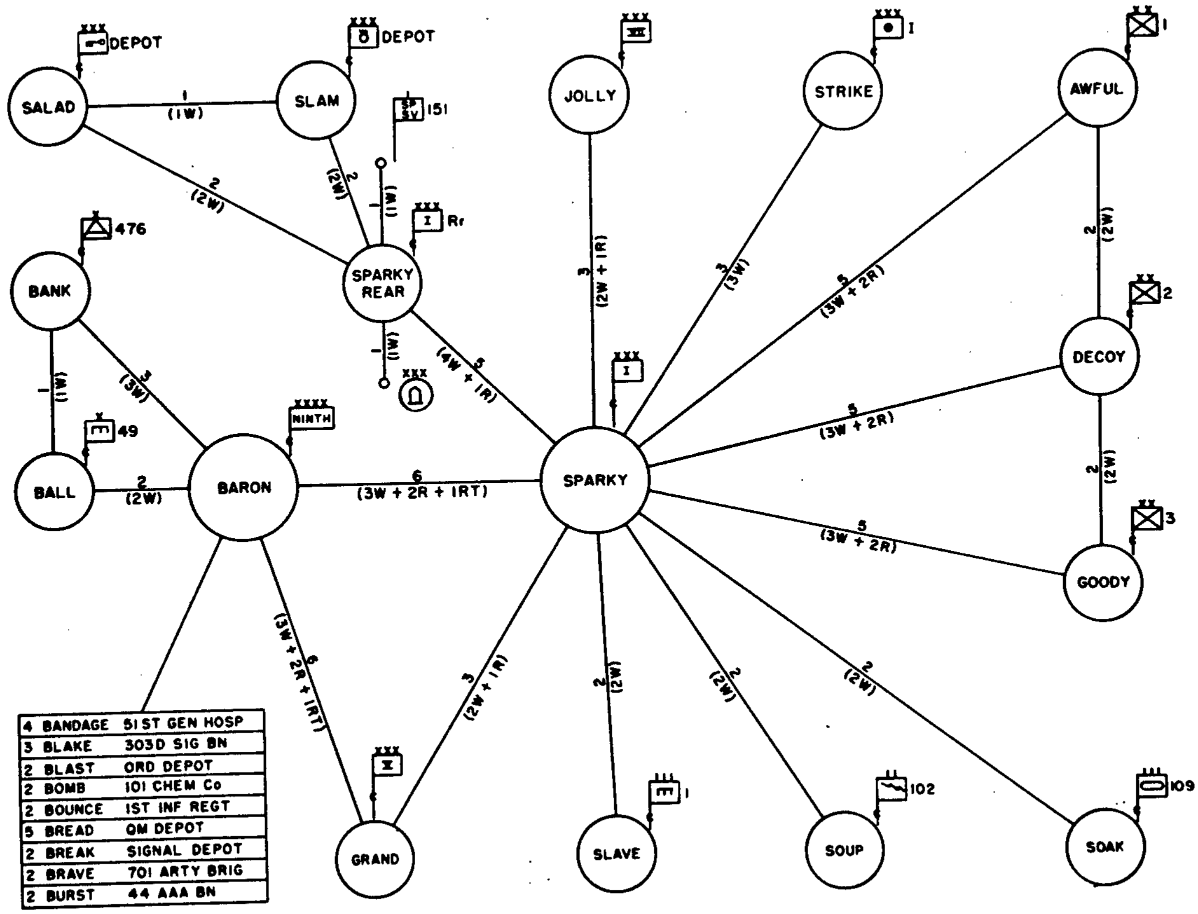
See Figs. 4 and 5.

[12]U.S. Army Electronic Proving Ground, USAEPG SIG 940-26, p. 2.

[13]U.S. Army Electronic Proving Ground, SIG CCD 58-4, Vol. I, pp. iii, iv.

[14]*Ibid.*, p. 13.

TELEPHONE TRAFFIC DIAGRAM
I CORPS
EFFECTIVE 150300 JUNE 1950



4 BANDAGE	51 ST GEN HOSP
3 BLAKE	303D SIG BN
2 BLAST	ORD DEPOT
2 BOMB	101 CHEM Co
2 BOUNCE	1ST INF REGT
5 BREAD	QM DEPOT
2 BREAK	SIGNAL DEPOT
2 BRAVE	701 ARTY BRIG
2 BURST	44 AAA BN

JOHN DUNLOP
COL SIG-C
SIGNAL OFFICER

NOTE:
THE COMMANDER MAY PROHIBIT THE USE OF UNIT DESIGNATIONS OR SYMBOLS WHEN SIGNAL SECURITY IS JEOPARDIZED

TM 462-77

Figure 4. Example of a Traffic Diagram.[a]

[a]Officers' Department, The Signal School, Communications Tactical Wire Records Reference Data, ("Instructional Material W 14/1"; Fort Monmouth, N.J.: 15 October 1952), p. 14.

Communication designator	Served by	Unit	Location (coordinates)	Teletypewriter routing indicator or call sign
MONARCH 752	MONARCH 710	42nd Missile Battalion (HERCULES)	437831	KY3
MONARCH 785	MONARCH 713	89th Engineer Battalion	495672	DR 6
*	*		*	*

Figure 5. Example of a Locator Register[a]

[a]U.S. Department of the Army, Tactical Signal Communication Systems, Army, Corps, and Division, FM 11-21, (Washington: U.S. Government Printing Office, 21 November 1961), p. 53.

To remedy this deficiency the committee recommended that the system control and information section provided in the army area signal group headquarters be deleted and its functions absorbed by the communications division of the army signal staff.[15] This division would establish a signal operations control center which would exercise operational control on a 24-hour basis over the army area communications system in the same manner that the tactical operations center controlled tactical units.[16] Its major functions would be to:

1. Perform traffic engineering.
2. Perform transmission engineering.
3. Perform frequency allocation and supervise frequency control.
4. Prepare plans and drawings, publish circuit diagrams and line route maps.
5. Issue instructions for the installation and maintenance of wire and radio communications for use by the army headquarters and army troops.
6. Inspect wire and radio installations and recommend changes and improvements.
7. Prepare, plan, and provide test procedures to insure adequate transmission quality of circuits.
8. Prepare and issue traffic diagrams.
9. Perform analysis, prepare plans, and issue instructions for the increase or decrease of signal communication facilities.
10. Assign code names, call signs, and system and circuit numbers.
11. Assign circuits and supervise circuit control.
12. Provide locator, directory, and information service for the entire command.[17]

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[15] U.S. Army Electronic Proving Ground, "Annex H, Communications Systems and Facilities Control," SIG CCD 58-4, Vol. IV, H p. 4.

[16] Ibid., H pp. 3, 5-6.

[17] U.S. Army Electronic Proving Ground, "Tab A to Appendix H-6 to Annex H, Sample Communications System Control and Signal Information Service Standing Operating Procedure," SIG CCD 58-4, Vol. IV, H-6A pp. 2-3.

The committee examined the methods of identifying signal centers, organizations, systems, and circuits developed by the 1958 study group, but made no changes. Their discussion was largely copied word-for-word from the earlier study.[18]

The list of records which the signal operations control center would maintain was considerably expanded beyond that of the 1958 study. In addition to the signal situation map and the traffic diagram the control center would prepare and utilize a systems diagram and a radio relay systems map.[19] Other records included:

1. Unit locator register.
2. Circuit order and record cards.
3. Circuit requests from using units.
4. Circuit register, listing all allotted circuit numbers and their use.

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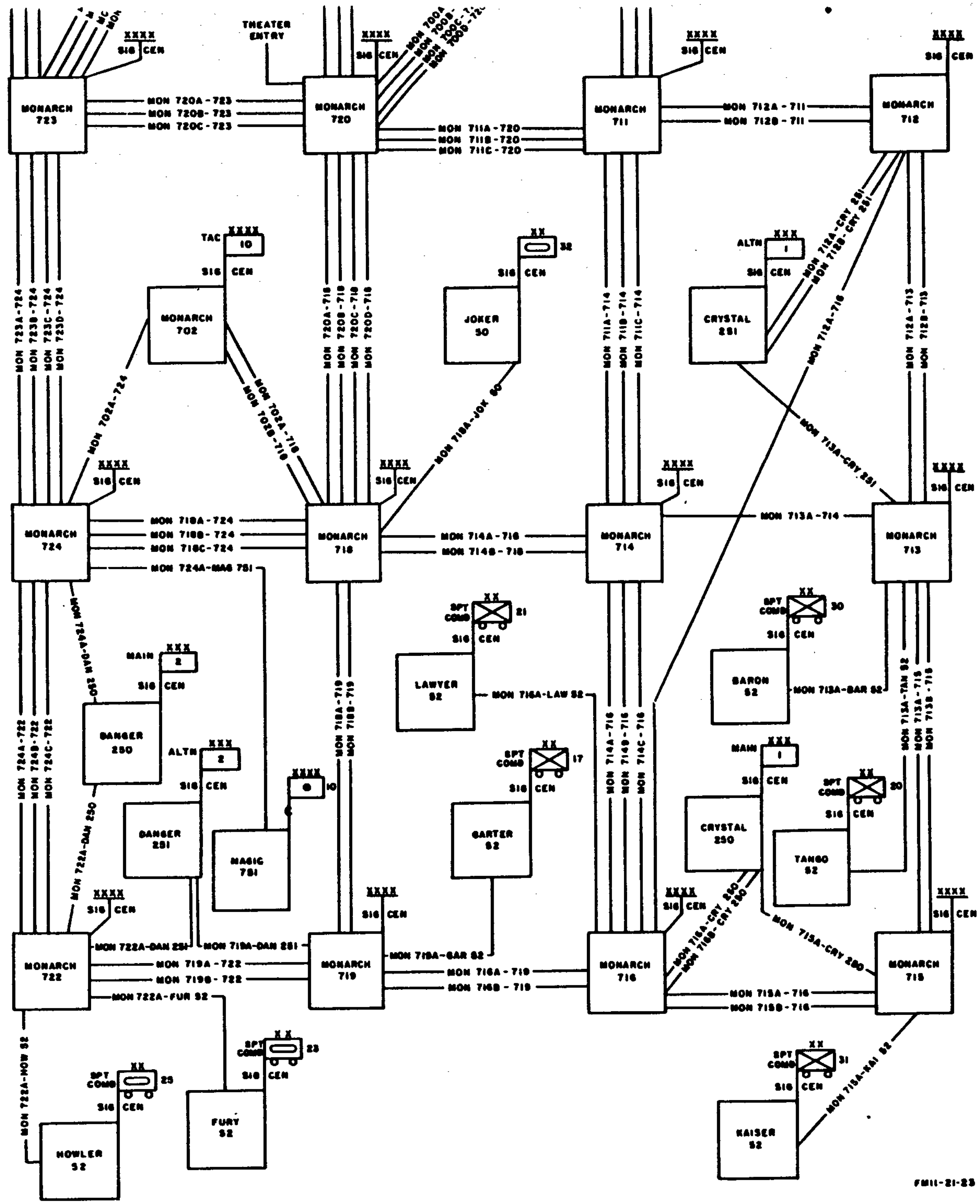
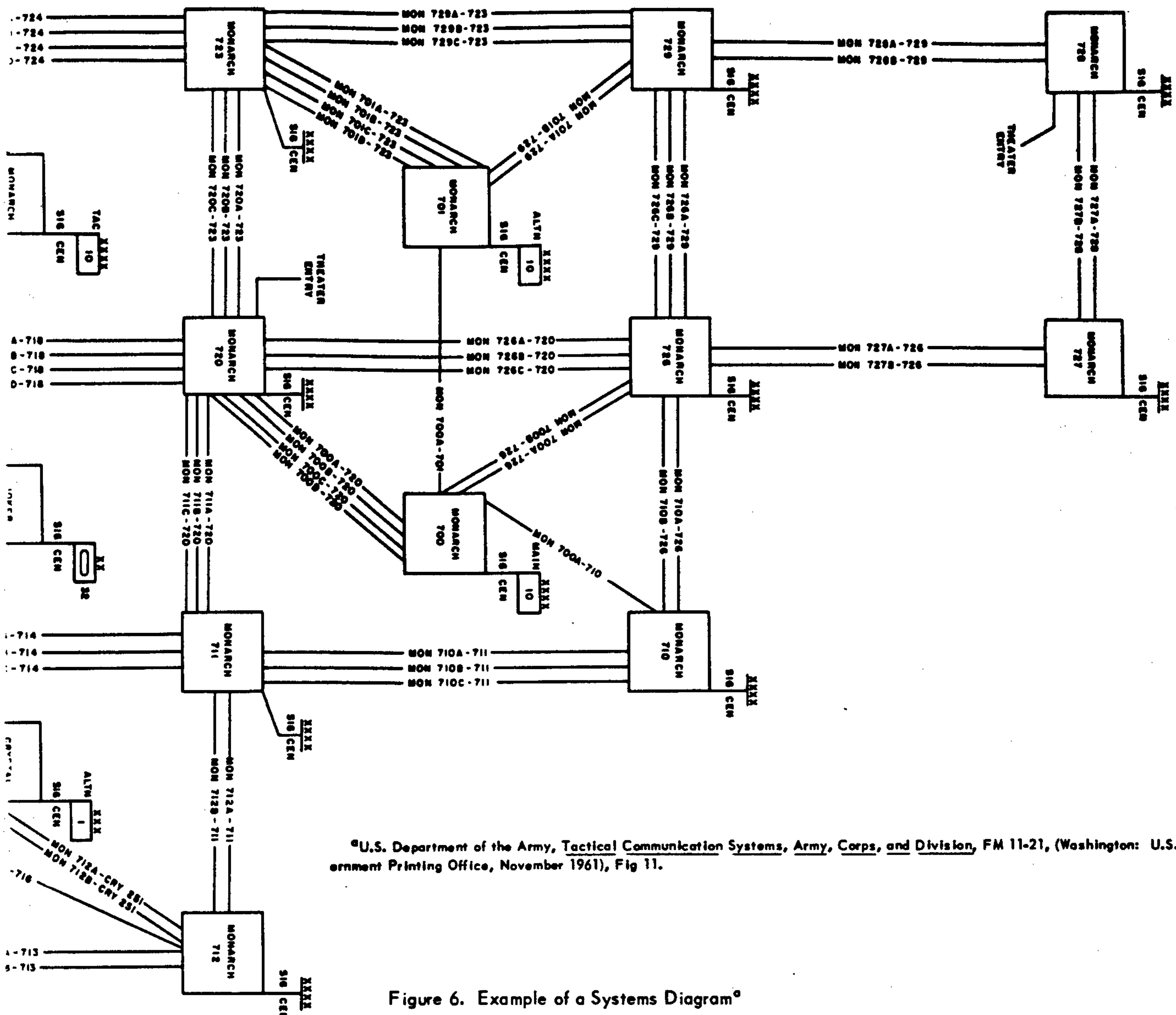
[18]E.g., U.S. Army Electronic Proving Ground, "Annex E, Systems and Circuit Designation," USAEPG SIG 940-26, pp. 1-2 largely corresponds to U.S. Army Electronic Proving Ground, "Tab A to Appendix 5 to Annex H, Operational Control Procedures, 1962-65 Army Area Communications System," SIG CCD 58-4, Vol. IV, H-5A pp. 10-11. See above, pp. 68-71.

[19]U.S. Army Electronic Proving Ground, "Appendix H-8 to Annex H, Records and Reports for Systems Control, 1962-1965," SIG CCD 58-4, Vol. IV, H-8 pp. 1-2.
The systems diagram is a schematic diagram showing the signal centers in operation, their general geographical relationship to each other, and the multichannel systems connecting them. No attempt is made to show actual location or type of transmission media. See Fig. 6.
The radio relay systems map is a map overlay showing terminal elevations and locations, frequencies, azimuth of antenna orientation, and locations of radio relay repeater stations. See Fig. 7.



MONARCH 723
MONARCH 720
MONARCH 711
MONARCH 712
MONARCH 702
MONARCH 724
MONARCH 718
MONARCH 714
MONARCH 713
MONARCH 722
MONARCH 719
MONARCH 716
MONARCH 715
THEATER ENTRY
JOKER 50
CRYSTAL 251
CRYSTAL 250
DANGER 250
DANGER 251
MAGIC 751
LAWYER S2
GARTER S2
BARON S2
TANGO S2
HOWLER S2
FURY S2
KAISER S2
SIG CEN
SPT COMD
TAC
MAIN
ALTN
XXXX
XXX
XX
MON 720A-723
MON 720B-723
MON 720C-723
MON 711A-720
MON 711B-720
MON 711C-720
MON 712A-711
MON 712B-711
MON 723A-724
MON 723B-724
MON 723C-724
MON 723D-724
MON 720A-718
MON 720B-718
MON 720C-718
MON 720D-718
MON 711A-714
MON 711B-714
MON 711C-714
MON 712A-713
MON 712B-713
MON 702A-724
MON 702A-718
MON 702B-718
MON 718A-JOK 50
MON 712A-CRY 251
MON 712B-CRY 251
MON 712A-716
MON 713A-CRY 251
MON 718A-724
MON 718B-724
MON 718C-724
MON 724A-MAG 751
MON 714A-716
MON 714B-716
MON 713A-714
MON 724A-DAN 250
MON 724A-722
MON 724B-722
MON 724C-722
MON 722A-DAN 250
MON 718A-719
MON 718B-719
MON 716A-LAW S2
MON 714A-716
MON 714B-716
MON 714C-716
MON 713A-BAR S2
MON 713A-TAN S2
MON 713A-715
MON 713B-715
MON 722A-DAN 251
MON 719A-DAN 251
MON 719A-GAR S2
MON 719A-722
MON 719B-722
MON 716A-719
MON 716B-719
MON 722A-FUR S2
MON 716A-CRY 250
MON 716B-CRY 250
MON 715A-CRY 250
MON 715A-716
MON 715B-716
MON 722A-HOW S2
MON 715A-KAI S2

FM11-21-23



[a]U.S. Department of the Army, Tactical Communication Systems, Army, Corps, and Division, FM 11-21, (Washington: U.S. Government Printing Office, November 1961), Fig 11.

Figure 6. Example of a Systems Diagram[a]

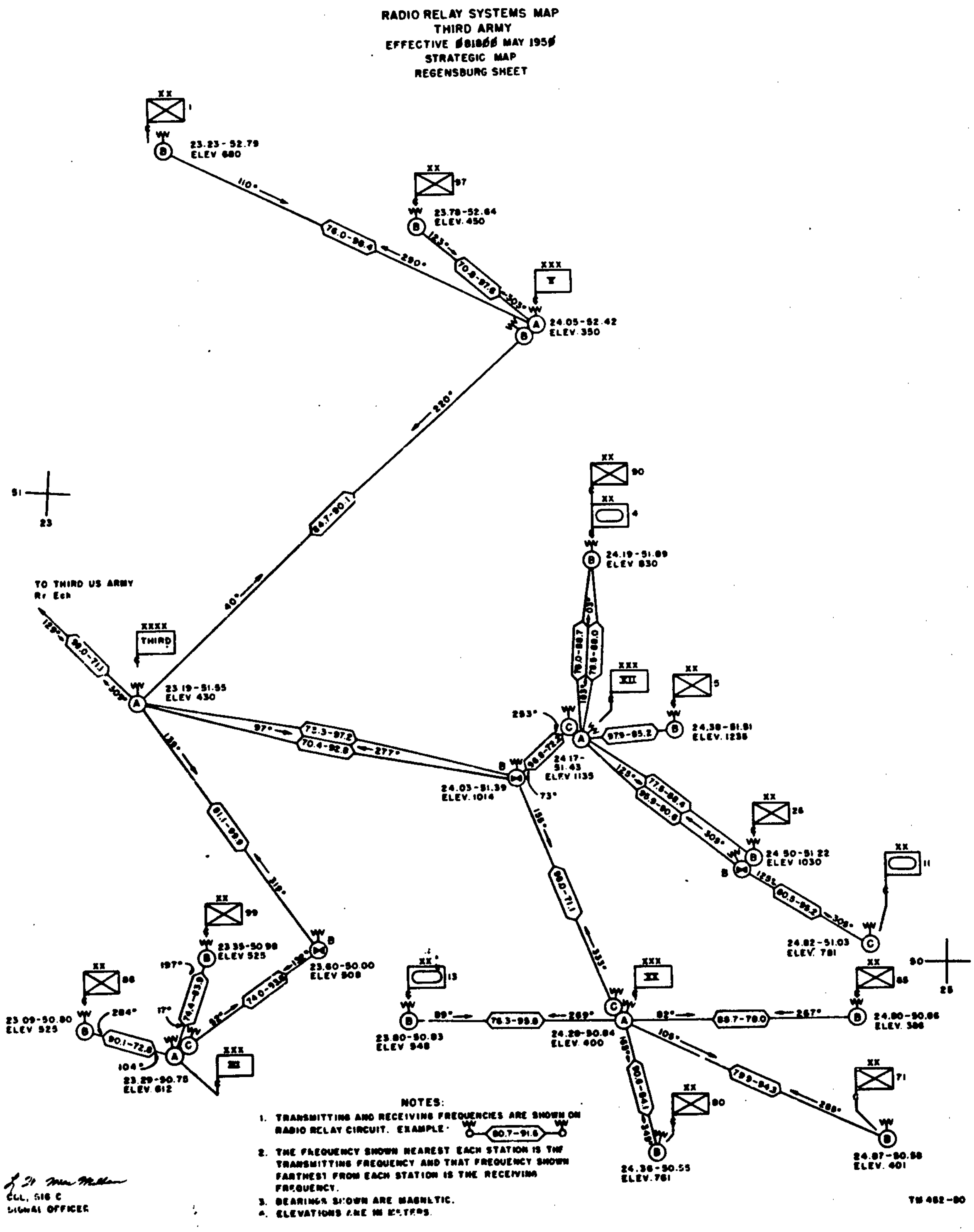


Figure 7. Example of a Radio Relay Systems Map*

*Officers' Department, The Signal School, Communications Tactical Wire Records Reference Data, ("Instructional Material W 14/1"; Fort Monmouth, N.J., 15 October 1952), p. 26.

5. Carrier system record cards, showing the use of each channel of the carrier system, numbers of the circuits routed over the system, and their terminations.

6. Circuit outage record, a temporary chart listing circuits out of order, when failure occurred, the nature of the trouble, when the circuit was expected to be restored, and the time actually returned to service.

7. Group routing record, listing the terminations of each trunk group in service and their routing.[20]

The study of 1958 did not mention orders or reports. This oversight was corrected by the 1960 committee, which noted that the officer-in-charge of the system control and signal information section of the army signal group was responsible for issuing detailed instructions to the operating elements in the fields of traffic control, system engineering, and signal information service.[21] The operating elements would provide the system control section information which it needed to control effectively the operations of the communications system. The reports which the committee regarded as essential were the <u>completion report</u>, announcing compliance with a communications order; the <u>emergency service report</u>, providing information about service rendered to a transient unit; a <u>displacement report</u>, announcing

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[20]<u>Ibid</u>., H-8 pp. 2-3.

[21]U.S. Army Electronic Proving Ground, "Tab A to Appendix 2 to Annex H, Organization, Army Area Signal Group," <u>SIG CCD 58-4</u>, Vol. IV, H2-A p. 2.

the closing of a signal center for movement and which circuits were rerouted; outage reports of circuit failure lasting more than sixty seconds, including reports when the circuit was returned to service; service reports of communications support provided to a using unit as previously directed; and traffic summaries, showing the number of telephone calls and teletype messages handled by the reporting element.[22]

U.S. Army Field Manual, Tactical Signal Communication Systems, Army, Corps, and Division, FM 11-21, 1961

The present official U.S. Army doctrine for tactical systems control, FM 11-21, was published a little more than one year after the Electronic Proving Ground committee had submitted their report. While portions of FM 11-21 appear to have been derived from the 1960 study, the manual as a whole is much more general in nature. It omits, for example, the detailed guidance such as the sample systems control SOP which the 1960 committee had included in their report.

FM 11-21 considered the requirement for signal communications control to be divided into three parts: communications control, concerned with planning and operations and defined as "the process by which communications resources are matched with communications requirements

[22] U.S. Army Electronic Proving Ground, "Appendix H-8 to Annex H, Records and Reports for Systems Control, 1962-1965," SIG CCD 58-4, Vol. IV, H-8 pp. 1-3.

generated by the overall mission of the command"; systems control, "the detailed engineering and operation of multichannel systems at each applicable level of signal command"; and circuit control, "the engineering of individual circuits between one or more signal centers or subscribers to meet the requirements of the army signal plan."[23] In other words, communications control is primarily concerned with long-range general planning and the conversion of the signal plan, when approved by the commander, into mission-type orders to subordinate signal units. Systems control and circuit control are day-to-day functions which translate the guidance of the signal plan or interpret the instructions of the combat order to produce detailed technical instructions for the operation of the communications system.

At the time FM 11-21 was written the systems control function for the field army was carried out by the systems control and information section of the combat area signal group, which established main and alternate systems control centers. The functions of the systems control center specified in FM 11-21 were to:

1. Prepare and issue detailed systems and circuit orders to implement the orders and directives of the field army signal officer.

2. Coordinate the operation of the network to facilitate integration of the field army area system with

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[23]U.S. Department of the Army, Tactical Signal Communication Systems, Army, Corps, and Division, FM 11-21, (Washington: U.S. Government Printing Office, November 1961), p. 41.

systems installed by subordinate (corps and division) and coequal commands (air force and navy).

3. Analyze traffic to determine the current efficiency of the network, and compile experience data for future references.

4. Prepare and issue rerouting directives and plans based upon circuit priorities furnished by the army signal officer.

5. Establish and operate a signal information service which collects, records, and disseminates signal directory service and communication-routing information to all components of the field army communication system.

6. Coordinate the field army area messenger service.

7. Advise commanders of signal units on the location and displacement of individual army area signal centers.

8. Maintain detailed records reflecting the current communications situation.

9. Establish standard control procedures for all subordinate control centers and exercise control of the field army area communication system through these subordinate control centers.[24]

FM 11-21 retained the method of identifying signal centers, organizations, systems and circuits previously developed by the U.S. Electronic Proving Ground, but added

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[24] Ibid., p. 42.

a method for identifying a system in terms of the type of service (telephone or telegraph), the transmission medium used, and the number of telephone or telegraph channels furnished by the system. If system MON 711-712 were an eight-channel telegraph system operated over spiral-four cable its full designator would appear as MON 711-712 TG/S/8, where the letters TG indicate a telegraph carrier system, S denotes a spiral-four cable transmission medium, and 8 shows the number of channels in the system. System MON 711-DAN 250, providing both telephone and telegraph channels over a radio relay link, would be designated MON 711-DAN 250/V/11/4.[25]

The list of records for systems control purposes contained in FM 11-21 was similar to that of the 1960 Electronic Proving Ground study with certain additions and deletions. The line route map, radio net diagram, and the telephone route bulletin were added; the circuit outage record and the group routing record deleted.[26]

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[25] Ibid., p. 47. In the second example the letters TP (for telephone system) are omitted as unnecessary; the letter V (for VHF) is used to indicate a radio relay system. The first figure (11) gives the number of telephone channels; the second figure (4) the number of telegraph channels. By strict adherence to the doctrine of FM 11-21 the superimposed telegraph carrier system should have a separate system designator.

[26] Ibid., pp. 52-57. See above, pp. 75-78.

The line route map is a map overlay showing the exact route of wire and cable lines, type of construction, type of wire or cable, and the number of conductor pairs available. Its use is restricted to those instances where wire or cable is employed as a transmission medium. See Fig. 8.

The radio net diagram is a graphic display

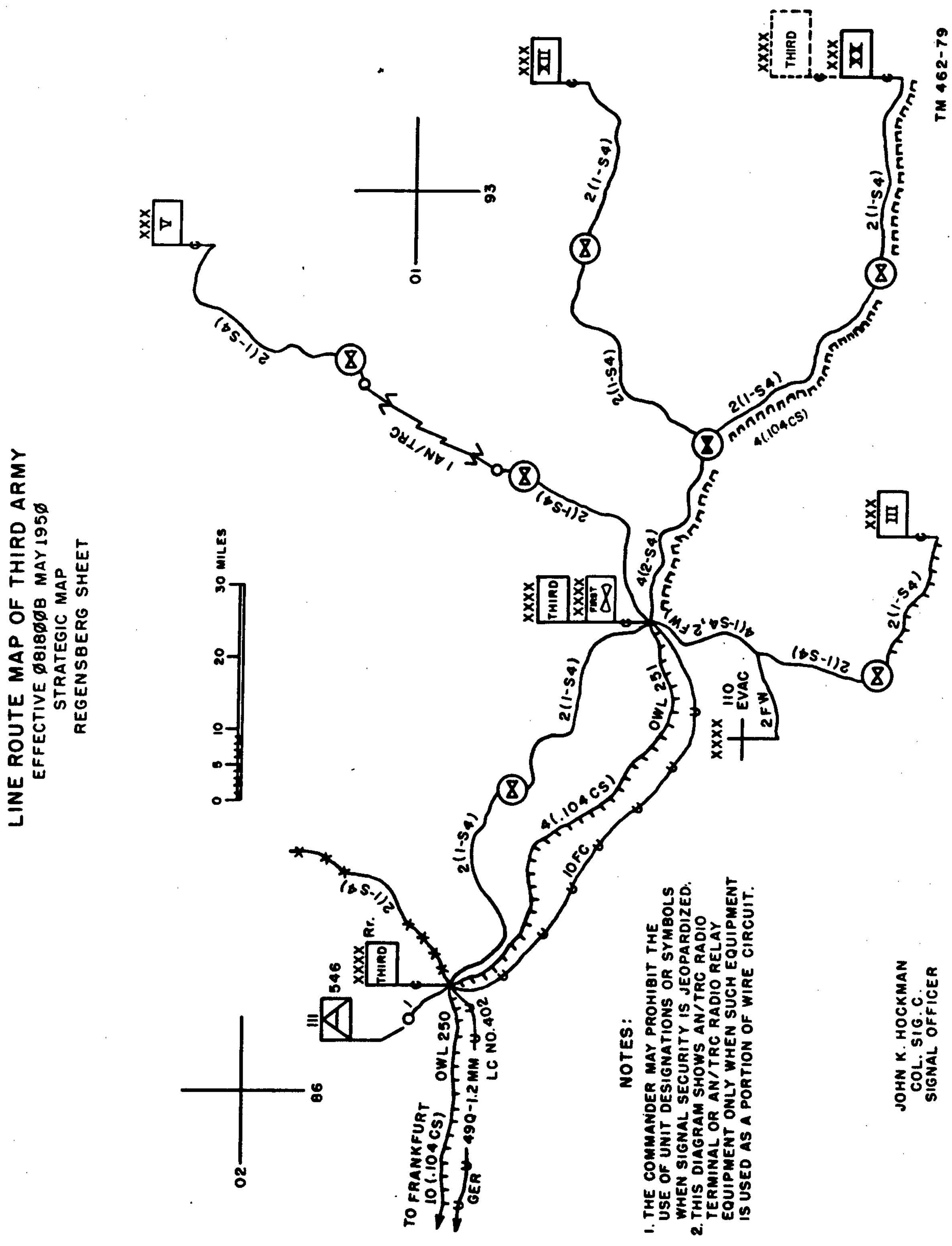

Figure 8. Example of a Line Route Map.[a]

[a]Officers' Department, The Signal School, <u>Communications Tactical Wire Records Reference Data</u>, ("Instructional Material W 14/1"; Fort Monmouth, N.J.: 15 October 1952), p. 28.

Orders and reports are mentioned in FM 11-21, but no guidance was furnished concerning their format or information which they should contain. The sole exception was the statement that "the contents of the circuit order and record card are transmitted in abbreviated format and constitute a circuit installation order to the signal center involved."[27]

U.S. Seventh Army, 1966

Doctrine is seldom evolved in time to guide the field units in their attempts to cope with new equipment or new organizations. This was the case with the U.S. Seventh Army in West Germany, which had organized and deployed an army area communications system over a year before FM 11-21 was published. It developed its own methods of systems control which bore little relation to the procedures of FM 11-21. These were revised and refined during the period 1960-1965. In 1966 systems control procedures were completely rewritten to make maximum use of punched card

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showing the use of radio sets within a given organization or area. It shows the type and number of sets, frequencies, call signs, and other information as necessary.

Sole-user traffic diagrams are schematic presentations of the origin, number, and termination of approved sole-user circuits.

Telephone route bulletins are alphabetical listings of organizations or units by telephone directory name or unit designator, showing the signal centers serving each listed unit. They serve the same purpose as the traffic diagram, and are necessitated by the large number of units in the field army requiring access to the area communications system.

[27] *Ibid.*, p. 56.

equipment then coming into use for command control purposes.

Signal support for Seventh Army is provided by the Seventh Army Communications Command, which functions as a field army signal brigade. Systems control is exercised by a signal operations center (SOC), which includes both control and engineering elements organized under the operations section of the communications command staff. This agency is responsible for all systems, circuit, and traffic engineering, liaison with corps and division signal officers, establishment of technical standards, operation of the signal information service, and the technical direction necessary to establish and reroute systems and circuits. It also analyzes reports from the operating elements and provides information concerning the status of the army communications network to the commanding officer of the communications command and his staff as required.[28]

Using units and signal centers are designated by a two-character alpha-numeric code. System designators combine the signal center designators of the controlling terminal and the distant terminal with a letter (V, S, M) to show the type of operation (radio relay, spiral-four cable, or a combination of radio relay and spiral-four cable), and a one-digit number to designate the first, second, or additional systems between the indicated terminals. For example,

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[28]Interview with Major Ray H. Lee, Assistant Plans Officer, Signal Section, U.S. Seventh Army (1965-1966), 16 March 1967.

system A1F1V1 is the first radio relay system established between headquarters A1 and F1. Circuits are assigned a six-character circuit designator composed of a one-digit number to show the purpose of the circuit (sole-user, common-user, secure teletypewriter, etc.), the "from" and "to" signal center designators, and a two-digit circuit number. Blocks of circuit numbers are allocated to using elements such as the army G-3 section, G-4 section, etc.[29]

The basic control records maintained by the signal operations center include an army systems diagram, a unit locator register, and a circuit routing chart. The last-named document is a list of information about systems and circuits which is kept on data cards and printed as required. Changes are prepared on a daily basis. The first section of the circuit routing chart is an index to all systems and circuits. The second section contains information about installed systems. A page is prepared for each system giving the system designator and the complete routing of each circuit utilizing a channel of the system. Complete information about the radio path, such as terminal locations, antenna azimuths, frequencies, and site elevations is also included.[30]

Status reports are required whenever a station is out of operation for more than three minutes, or systems or circuits fail for more than ten minutes. Reports are prepared in automated format. They include the designator of

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[29] Ibid.

[30] Ibid.

the reporting signal center, the system or circuit designator, the time of failure or restoral, and the reason for failure. Initial status reports use a different format from those which announce changes in system or circuit status.[31]

Communications operations orders are prepared by the signal operations center and transmitted over the systems control sole-user network to the operating signal battalions for action. The message heading utilizes a prescribed format; the body of the order is prepared in narrative form.[32]

Seventh Army systems control procedures are constantly changing and evolving as the capabilities and limitations of automatic data processing methods are more fully understood and new ideas for refining systems control direction and reporting are formulated.

U.S. Eighth Army, 1966

U.S. Eighth Army has retained the single-axis system of communications. It exercises systems control

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[31]Signal Section, Headquarters Seventh Army, Seventh Army Operational Control Complex Reporting Procedures, ("Command and Area Communications System Standard Operating Procedures, Item Nr. 1B-1"; APO [New York] 09046: 28 September 1966), pp. 5-9. (File No. N-17589.93, Fort Leavenworth, Kansas Library).

[32]Headquarters, Seventh Army Signal Section (SYSCON), Processing Communications Operations Orders (COO), ("SOP Item 1-01 (OPS)"; APO New York 09047: n.d.), pp. 1-3. (File No. N-17589.92, Fort Leavenworth, Kansas Library).

activities through the signal operations section of the army headquarters which is collocated with the army signal battalion operations section when in the field. The signal operations section has responsibility for all communications control functions, including frequency control, systems and circuit engineering, and signal information service.

The number of subordinate signal centers is small, since under the single-axis concept army only provides communications to its major subordinate headquarters. These are identified by a two-digit number, which also serves to identify the signal operating element at that echelon. To assist in visualizing systems routing, the Korean peninsula is divided into geographical areas, each of which is assigned a two-digit number. Systems designators are formed by combining the headquarters number of the controlling terminal and its geographical number, the letters A, B, etc. to designate the first, second, or additional systems between the headquarters, and the headquarters number and geographical number of the distant terminal. For example, system 2002A4003 is the first system established between headquarters 20, located in region 02, and headquarters 40, located in region 03. Circuits are designated by a six-digit number. The first four digits are the headquarters numbers of the near and distant terminals; the last two digits the circuit number. Blocks of circuit numbers are reserved for sole-user, common user, and teletypewriter circuits.

Records maintained at the signal operations section include an army circuit diagram, a systems diagram, a circuit register, and a circuit outage record.[33]

Reports are submitted immediately when a system or designated circuit becomes inoperative and when service is restored over the system or circuit. Daily traffic summaries are also required from signal centers.

All communications instructions are transmitted to the operating elements by telephone or personal contact. No special format is prescribed.[34]

<u>U.S. Army Combat Developments Command, Study, Improved Applications of Manual Signal Systems Control and Signal Information Service, for the Field Army Command and Area Communications Systems, 1965-1970, 1966</u>

The great increase in field army communications requirements and capabilities discussed in the TACOM study

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[33]The <u>circuit diagram</u> is a schematic record which shows the signal centers in operation, their general geographic relationship to each other, and the transmission media connecting them. It also uses appropriate symbols to provide information about the type of transmission media employed, the number of channels of a multichannel system, the type of carrier equipment employed, repeaters (if installed), where systems are terminated, and circuit designations. A circuit can be traced on this diagram from one terminal through all intermediate relay points to the distant terminal. The circuit diagram provides essentially the same information about the communications network that a schematic diagram provides for a piece of equipment in the network. See Fig. 9.

[34]Interview with Major Ernest Marmaras, Operations Officer (1965-1966), U.S. Eighth Army Signal Section, 18 February 1967.

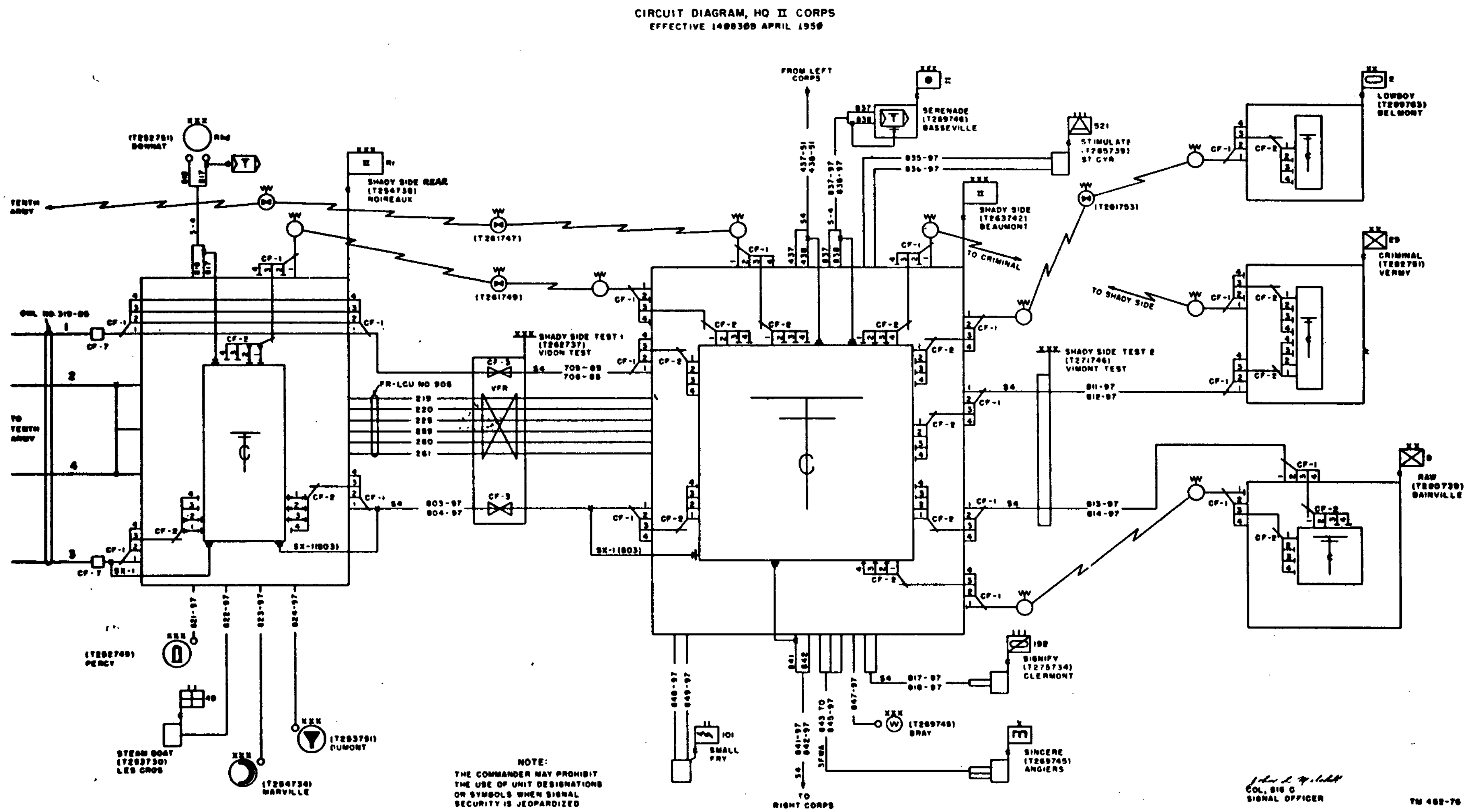

Figure 9. Example of a Circuit Diagram.[a]

[a]Officers' Department, The Signal School, Communications Tactical Wire Records Reference Data, ("Instructional Material W 14/1"; Fort Monmouth, N.J.: 15 October 1952), p. 12.

of 1964 prompted army planners to review the existing doctrine for systems control to determine its application to the proposed reorganization of the field army signal service and the new family of equipment being developed. In October 1965 the U.S. Army Combat Developments Command Combined Arms Group was directed to study the existing manual procedures for systems control and signal information service of the field army area and command communications systems with the objective of developing improved manual methods for carrying out these functions.[35]

The resulting study was conducted within the framework of the TACOM concept. It did, however, recommend certain organizational changes within the headquarters element of the army signal brigade as developed in the TACOM study. The signal brigade staff of TACOM consisted of four elements: the administrative and personnel section (S-1); the operations and intelligence section (S-2 and tactical functions of the S-3); the logistic section (S-4); and the systems control section (the technical functions of the S-3). The last-named staff section operated under the control of the brigade S-2/S-3 and was assigned the functions of:

1. Communication system planning.
2. Supervision of the communications system.

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[35]U.S. Army Combat Developments Command, "Annex A, Study Directive," to Study, Improved Applications of Manual Signal Systems Control and Signal Information Service, for the Field Army Command and Area Communications Systems, 1965-1970 (U), (Coordination Draft; n.p.: June 1966), p. A-1. (File No. N-18538.40, Fort Leavenworth, Kansas Library). (FOR OFFICIAL USE ONLY).

[redacted]

3. Traffic analysis and control.

4. Signal information service.

5. Circuit engineering.

6. Centralized technical direction of the army command and area communications systems.[36]

The follow-on study proposed a combined systems control and operations section under the staff supervision of the brigade S-3. This section would have five branches: the section headquarters, exercising operational control over the other four branches; the signal systems engineering branch; the traffic engineering branch; the signal information branch; and the systems control and operations branch. The last-named branch would have the responsibility for:

1. Allocation of circuits based on established priorities.

2. Ensuring circuit route availability by maintaining centralized control of circuits.

3. Ensuring effective communications service by directing subordinate battalions to reroute circuits as required.[37]

These functions were to be exercised from a main and an

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[36] U.S. Army Combat Developments Command, CD Study . . . TACOM, Vol. II, pp. 3-59--3-60.

[37] U.S. Army Combat Developments Command, "Annex F, Organization," to Study, Improved Applications of Manual Signal Systems Control, . . . pp. F-1--F-9.

[redacted]

Removed per Maj. Miller SC Memo dtd 15 Jul 99

alternate systems control facility located near the army main and alternate command posts.[38]

The study group concluded almost immediately that no improvement in manual systems control procedures could be realized, recommended the deployment of a systems control computer concurrently with the new generation of multichannel PCM equipment, and proceeded to develop automated methods for systems control to be used with a computer.[39]

Systems and circuits would be designated by reference to the user. For this purpose a user designator (a two-character alpha-numeric code) would be assigned to each using headquarters or operating facility, including elements of the theater command, subordinate corps, divisions, and signal centers.[40] Circuit designators would be composed of numbers and letters to indicate the circuit number, type of circuit (data, facsimile, telephone, or teletypewriter), priority, and signal centers and channels over which the circuit was routed. An explanation of this circuit numbering system is given in Figure 10. The method of constructing system designators was not clearly expressed in the study.

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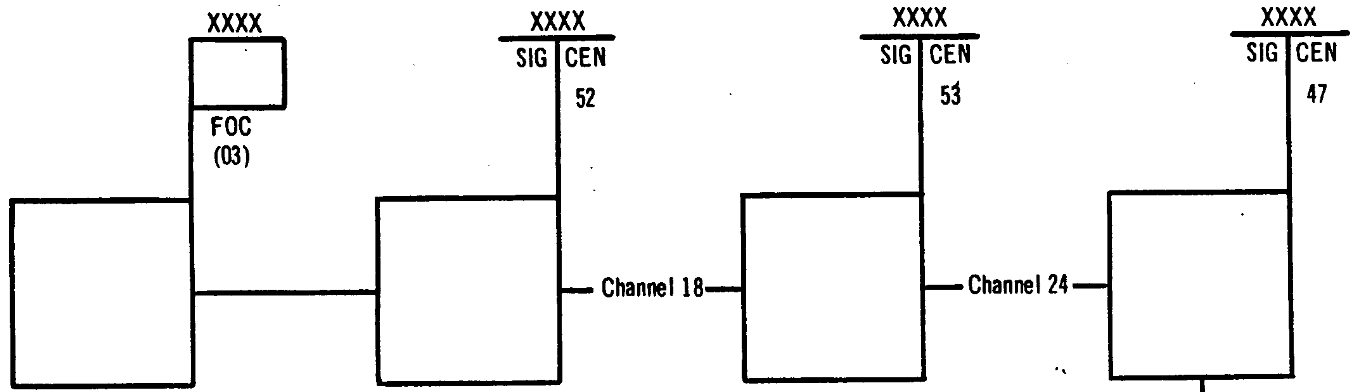
[38] Ibid.

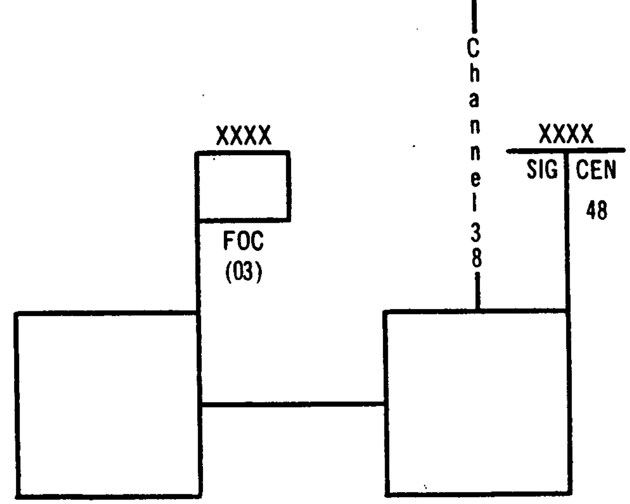
[39] U.S. Army Combat Developments Command, Study, Improved Applications of Manual Signal Systems Control, . . . p. iv.

[40] U.S. Army Combat Developments Command, "Annex H, System and Circuit Numbering Scheme," to Study, Improved Applications of Manual Signal Systems Control, . . . pp. H-1--H-7.

Removed per Maj. Miller, SC. memo dtd 15 Jul 99

[redacted]





CIRCUIT NUMBER:

184003V2521853244738000000000000004803

EXPLANATION:

1840	4-digit circuit number
03	"near end" user
V	voice (telephone) circuit
2	circuit priority
52	first area signal center operating the circuit
18	channel number from first signal center
53	second signal center
24	channel number from second signal center
47	third signal center
38	channel number from third signal center
0000...	spaces reserved for additional connections if necessary. Not used in this example.
48	final (terminal) signal center
03	"distant end" user.

NOTE:

This example is factually meaningless, since the duplication of the user number for both "near end" and "distant end" users implies that the circuit originates and terminates in the same location.

Figure 10. Schematic Explanation of a Circuit Number[a]

[a]U.S. Army Combat Developments Command, "Annex H, System and Circuit Numbering Scheme," to Study, Improved Application of Manual Signal Systems Control, . . . pp. H-1–H-8.

[redacted]

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Maj. Miller, SC
Per memo dtd
15 Jul 99

Five circuit priorities were established:

1. Priority one--"signal engineering" and systems control.
2. Priority two--"operations critical" circuits which cause a gap in command and control.
3. Priority three--"operations necessary," such as movements control, missile weapons control and critical items of supply.
4. Priority four--"command common user."
5. Priority five--"area common user."[41]

Records which systems control centers would maintain are the same as those prescribed in FM 11-21.[42] Each operational installation would also be required to keep a log of each day's operations to assist in the preparation of reports.[43]

Reports would be required under the following conditions:

1. When service is interrupted for a period of fifteen minutes or longer, and when service is restored. Minor interruptions of less than fifteen minutes are reported when service resumes. All trouble reports include the reason for the failure and actions taken to correct the trouble and restore service.

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[41] U.S. Army Combat Developments Command, "Annex E, Communication Systems Engineering and Control," to Study, Improved Applications of Manual Signal Systems Control, . . . pp. E-4--E-5.

[42] See above, p. 82.

[43] U.S. Army Combat Developments Command, "Annex G, Records and Reports," to Study, Improved Applications of Manual Signal Systems Control, . . . pp. G-1--G-4. A log provides a "record of operating conditions during the period of operation." (U.S. Department of the Army, Field Radio Techniques, FM 24-18, [Washington: U.S. Government Printing Office, July 1965], p. 108.).

[redacted] Removed per Maj. Miller SC memo dtd 15 Jul 99

2. When action required by a systems control directive has been accomplished.

3. To report equipment status and traffic handled during the previous twenty-four hour period.

4. When directed to report high-frequency utilization.

5. Upon change of location by a using unit.[44]

Orders to subordinate signal centers are classed as operations orders and may include instructions concerning signal center location and displacement, system engineering (installation, operation, maintenance, and discontinuance of systems and circuits), and allocations of facilities and equipment. They would be issued in the name of the signal brigade commander by the chief of the systems control section.[45]

U.S. Defense Communications Agency

While not a U.S. Army element, the systems control methods of the Defense Communications Agency (DCA) can scarcely be omitted in any discussion of the subject.

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[44] U.S. Army Combat Developments Command, "Annex G, Records and Reports," to _Study, Improved Applications of Manual Signal Systems Control_, . . . pp. G-4--G-5.

[45] U.S. Army Combat Developments Command, _Study, Improved Applications of of Manual Signal Systems Control_, . . . pp. 9-10.

U.S. Army Combat Developments Command, "Communications Order," in "Annex I, Definitions," to _Study, Improved Applications of Manual Signal Systems Control_, . . . p. I-2.

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The DCA is, in effect, the systems control element for the world-wide communications network of the Department of Defense. Organized in 1961, the DCA was given directive authority over the Defense Communications System (DCS). Its authority, termed "operational direction," was defined as the

> authoritative direction necessary to obtain and effectively operate a single long-line, point-to-point communications system for the Department of Defense. It includes, but is not limited to, authority to direct the operating elements of the DCS, to assign tasks to those elements, to prescribe the manner in which tasks will be performed, and to supervise the execution of those tasks.[46]

The Director, Defense Communications Agency, was directed to perform the functions of, and was given the authority to:

> Direct the restoration, allocation, or re-allocation of circuits and channels of the DCS, in accordance with established priorities.
>
> Operate Communications Control Centers; exercise operational direction over "departmental facilities/technical control" elements functioning as part of the DCS; and maintain current information on status of circuits, channels, and resources of the DCS.
>
> Prescribe the operation, maintenance, installation and personnel performance standards, practices, methods, and procedures of the DCS.[47]

These functions are carried out under the authority delegated to the Director, DCA, by subordinate Defense

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[46] U.S. Department of Defense, Directive 5105.19, 14 November 1961, Subject: "Defense Communications Agency," quoted in U.S. Defense Communications Agency, DCS Technical Control Procedures, DCS Circular 70-6, (Washington: 12 November 1964), p. 1.

[47] *Ibid.*

Operations Center Complexes established as required at various points throughout the world. These control centers exercise operational direction of DCS stations within their assigned geographical regions.[48]

The DCA maintains a complete and up-to-date directory of all trunks and circuits within the DCS using automatic data processing equipment and automatic display systems. The term "trunk," as used by the DCA, denotes a "communications capability, single or multichannel, between two terminal facilities . . . at which channels may be tested, rerouted, dropped out, or switched to another route."[49] It corresponds to the U.S. Army term "system."

Each trunk is designated by a six-character trunk identifier. The first two characters are alphabetic or numeric and show the "from" and "to" geographic regions in which the terminals are located. For this purpose the continental United States is divided into eight regions, the remainder of the world into nine. The third character of the trunk identifier is alphabetic and is used to identify the agency (U.S. Army, Navy, Department of State, etc.) operating the trunk. The fourth character, also alphabetic, indicates the type of trunk (the transmission medium). The fifth and sixth characters represent the

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[48] U.S. Defense Communications Agency, Operational Direction Manual of the Defense Communications System (DCS), DCA Circular 55-5, (Washington: 30 April 1964), p. 3-3.

[49] U.S. Defense Communications Agency, Directory Data Base Manual of the Defense Communications System (DCS), DCAC 55-2D, (Washington: November 1965), p. 1-1.

trunk number. They may be alphabetic, numeric, or a combination.[50]

Circuits are identified by assigning an eight-character Command Communications Service Designator (CCSD) to them. The first four characters are alphabetic; the first character indicates the agency requiring the circuit, the second and third characters the use or purpose of the circuit, and the fourth character the type of service (voice, data, teletypewriter, etc.) of the circuit. The last four characters are the circuit number. They may be alphabetic, numeric, or a combination of both.[51]

The primary control record used by the DCA is its circuit directory, prepared and maintained by automatic data processing techniques. Three types of data cards are used for directory purposes; the circuit directory card, the trunk header card, and the trunk trailer card.

A circuit directory card is prepared for each segment of the circuit. The following information is listed:

1. The geographical location of the "from" terminal. (An eight-character contraction).

2. The user or the operator of the "from" terminal. (A three-character code).

3. The state or country in which the "from" and "to" terminals are located. (Two two-digit codes).

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[50] _Ibid._, pp. 2-1, B-1, B-2, D-1, E-1.

[51] U.S. Defense Communications Agency, _DCAC 55-2D_, p. 1-4.

4. The trunk identifier of the circuit segment described. (Six characters).

5. The channel number of the trunk carrying the circuit. (Six digits; the first three digits indicate the voice channel, the last three the teletypewriter channel if applicable).

6. The geographical location of the "to" terminal. (An eight-character contraction).

7. The user or the operator of the "to" terminal. (A three-character code).

8. The type of operation of the circuit. (Full duplex, half duplex, etc.; one character).

9. The circuit CCSD. (Eight characters).

10. The number of the circuit segment being described. (Two characters).

11. The service availability code for the circuit. (Full-time circuits, circuits which may be activated on call of the user, etc.; one character).

12. Security equipment used on the circuit. (A two-digit code).

13. Circuit priority. (Two digits).

14. Cross reference to a teletypewriter trunk identifier, if applicable. (Six digits).

15. Commercial circuit number and owning corporation, if applicable. (Sixteen digits).

16. Miscellaneous information codes. (Three digits).[52]

Trunk header cards are prepared for all DCS trunks with certain minor exceptions. They list the "from" and "to" locations of the terminals, the type of terminating equipment, the code for the state or country where the terminals are located, the trunk identifier, channel capacity and bandwidth of the trunk, and other miscellaneous information.[53]

Trunk trailer cards are used in cases where the circuit card does not completely describe the circuit routing. They are mainly required at international border crossing points of commercial channels and at submarine cable terminations.[54]

A formal system of orders and reports has been established to provide the DCA control centers with the information needed to control the elements of the DCS within their area of responsibility and enable them to issue instructions to the operating agencies.

Control orders are referred to as operational direction messages and are numbered serially within the

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[52]U.S. Defense Communications Agency, DCAC 55-2D, pp. 1-1, 3-1--3-3.

A segment is a portion of a circuit between adjacent geographical locations where the circuit may be entered, terminated, or rerouted. It is the equivalent of a channel in tactical communications systems. Segments are numbered consecutively from one terminal to the other.

[53]*Ibid.*, pp. 4-1--4-3. [54]*Ibid.*, p. 5-1.

calendar year. They are used to direct actions to be taken by the operating elements of the DCS stations to which the message is addressed or to request information concerning the operational status of trunks, circuits, or traffic-handling facilities. Either voice or teletypewriter transmission may be used, depending on the availability of control circuits or the urgency of the message. DCS stations are required to take immediate action on messages addressed to them.[55]

Reports are normally submitted by teletypewriter in automated format so that the information which they contain can be automatically processed by the computer equipment located in the DCA operations centers. Narrative reports, which do not follow the automated format, are used to supplement automated reports by providing additional information about the status of the DCS which cannot be included in the rigid framework of the automated format, or to submit information of an emergency nature. They may be submitted by teletypewriter or voice means. Reports are required whenever communications are interrupted for a period of ten minutes or more, circuits are rerouted, or when the reporting station has untransmitted messages which equal or exceed its message-handling capability. This information must be reported at least every four hours; traffic reports are required hourly after the initial message is submitted,

[55]U.S. Defense Communications Agency, Operational Direction Manual of the Defense Communications System (DCS), DCAC 55-5, (Washington: 9 July 1963), pp. 3-9--3-10.

reporting inability to transmit messages within their statement of urgency (precedence). In addition, an "end-of-day" report is required for each station, giving its operational status as of 2400 hours Greenwich Mean Time (GMT). If there is no unreported information a negative "end-of-day" report is required.[56]

Teletypewriter reports use normal message headings prescribed for automatic or semi-automatic teletypewriter networks. The automated format begins with a signal which activates the computer. Subsequent information is submitted in eight types of automated format lines, each of which begins with its appropriate symbol. The types of lines are the:

1. S-line, identifying the station for which information is submitted. This line indicates the time of the report, and may also show a complete station failure and the reason if applicable.

2. T-line, identifying the station connected to the reporting station. This line may include traffic information.

3. K-line, listing the trunk which is inoperative or which has been restored, the time of outage or restoral, and the reason for outage.

4. V-line, reporting the status of a voice channel in the trunk listed in the preceeding K-line.

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[56]<u>Ibid</u>., pp. 4-5, 4-11--4-12, 8-9.

5. C-line, reporting the status of a teletypewriter channel in the trunk listed in the preceeding K-line.

6. A-line, used to show use of a channel by a previously-allocated circuit, for reroute of a higher priority circuit, or for return of the channel to the normal user.

7. U-line, reporting an inoperative circuit not caused by station, trunk, or channel failure.

8. D-line, giving the date and time the report was prepared.[57]

The report ends with computer instructions and the standard teletypewriter end-of-message indicator.

Reports are categorized as regular, special, emergency, recapitulation, or correction reports. Regular reports provide up-to-date information about the structure of the DCS. Special reports are rendered when special category circuits or facilities fail. Emergency reports provide information about "malicious interference with communications."[58] Recapitulation reports are submitted upon request of the DCA control center, and summarize the operational status of a station. Correction reports contain corrected information which was erroneously submitted in a previous report.[59]

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[57] _Ibid._, pp. 4-13, 5-5--5-6, 5-12.

[58] _Ibid._, p. 4-6. [59] _Ibid._

Summary

The examples of systems control doctrine discussed in this chapter indicate the divergency of methods and techniques which have been applied to the problem of controlling the modern communications system. None of these procedures have been developed with a view to their application to both manual and fully automated systems control methods. Some are not applicable in their present form to the current field army organization. Chapter V states the requirements which a modern tactical system control doctrine must have and discusses some of the shortcomings of the present methods of systems control.

CHAPTER V

SHORTCOMINGS OF PRESENT SYSTEMS CONTROL METHODS

Technical control of the field army communications network is a complicated problem. Its solution has grown more difficult due to the increased complexity of communications equipment, the demands for signal support, the greater mobility and more frequent displacement of communications users, the number and types of systems and circuits to be controlled, and the expansion of the field army signal organization to meet these requirements.

An effective tactical systems control doctrine must:

1. Be compatible with the organization and capabilities of the field army signal brigade.

2. Provide a control element with sufficient authority to direct changes in the field army communications network and insure that these changes are made rapidly and effectively. It must have adequate communications facilities to transmit its instructions rapidly to the executing agencies.

3. Provide centralized control of the communications network, while insuring that systems control actions are executed at the lowest possible level.

4. Provide a simple method for identifying communications operators and users in terms of their functions and their requirements.

5. Provide a simple and concise method for identifying systems and circuits.

6. Provide a system of communications records, reports, and orders which can be prepared and updated rapidly and efficiently by either manual or automated procedures.

A systems control doctrine which does not meet these requirements will be inadequate for the needs of the field army. The necessity for compatibility with the field army organization is obvious. Without a separate systems control element having adequate authority to direct routing changes in the communications network, the entire burden of detailed control must be borne by the signal organization commander alone--a task far beyond the capabilities of any single individual. Centralized control must be maintained to insure that the communications network functions as a single entity, and decentralized execution must be encouraged at the lowest echelon to provide the flexibility needed to react effectively to communications problems. The elements of the communications network must be simply and concisely identified if operating elements are to respond quickly and efficiently to changing communications needs. Records, reports, and orders must be simply and easily prepared and updated using either manual or automated procedures if the

communications network is to respond promptly to new demands and the requirements of combat.

The present U.S. Army doctrine for systems control, Field Manual FM 11-21, Tactical Signal Communication Systems, Army, Corps, and Division, was written in 1961, prior to the development of the field army command and area communications system proposed by the U.S. Army Combat Developments Command study, Field Army Requirements for Tactical Communications (TACOM). In the TACOM field army the communications network is installed and operated by a field army signal brigade consisting of two signal group headquarters and eight subordinate signal battalions. FM 11-21 places the responsibility for the systems control function upon the field army signal group, the senior field army signal organization at the time the manual was written. The tasks of traffic engineering and signal information service are included within the duties of the field army systems control center. The method of identifying communications users and signal centers outlined in FM 11-21 is cumbersome, since it requires an abbreviation of the telephone directory name as well as an arbitrary number. The procedure for constructing system designators yields an excessively long symbol, due to the unwieldy unit designators, identifying system terminals, which form part of the system designator. A system designator constructed in accordance with the guidance of FM 11-21 may vary from eleven to fifteen characters for the basic designator, with from five to seven

additional characters required to show the type of system, transmission medium, and the number of channels provided. This produces a symbol which not only uses an excessive number of characters (twenty-two maximum), but varies greatly in length. As a consequence this method is not applicable to automated systems control methods where brevity and uniform symbol length are desirable. Circuits are identified by the assignment of a four-digit number. No information about the type of circuit, purpose, terminals, or use is shown. Detailed procedures for the preparation of orders and reports are lacking.

U.S. Seventh Army provides an adequate organizational structure for the accomplishment of systems control actions. It uses a simple method for identifying communications users and signal centers, but does not differentiate between unit headquarters and sole-user circuit terminals. This step is desirable, since sole-user terminals have the highest priority for signal communications service within the field army and should be separately identified to insure that adequate service is promptly furnished to them. System designators in use by Seventh Army do not provide information about the number of channels or the type of system. Circuit designators are constructed by combining a one-digit symbol to show the type and purpose of the circuit, four characters giving the "from" and "to" terminals, and a two-digit circuit number. The use of a single code to show both circuit type and purpose is somewhat confusing, but the

inclusion of this information in the circuit designator is helpful in carrying out systems control actions since it permits rapid identification of the circuit and its relative importance. Seventh Army employs an automated format for the submission of reports, but continues to prepare communications orders in narrative form.

U.S. Eighth Army has retained the signal organization of the Korean War period. Its methods of systems control differ greatly from those of FM 11-21, but have been developed specifically for use on the Korean peninsula and do not appear to offer adequate guidance for systems control of the field army command and area communications systems.

The 1966 study of the U.S. Army Combat Developments Command, Improved Applications of Manual Signal Systems Control and Signal Information Service, for the Field Army Command and Area Communications Systems, 1965-1970 (U), provides for a separate systems control element within the field army signal brigade headquarters. It offers a simple system for designating communications users, but does not assign designators to sole-user circuit terminating agencies. The method of designating systems is not clearly explained in the study. Circuit designators proposed in the study give an exceptional amount of information about the circuit, but at the cost of excessive length and considerable confusion. Although the study refers to the entire sequence of characters as a circuit number, it is more accurate to speak of this construction as a circuit record, since

complete information about the circuit, including priority, type, and routing is provided. In actuality circuits are identified by the assignment of a four-digit number that appears at the beginning of the circuit designator. In spite of the fact that the study title refers to "manual signal systems control" procedures, the study presents only automated methods; manual procedures are not developed.

The U.S. Defense Communications Agency uses a fully-developed automatic data processing system to carry out its communications control functions. Its procedures provide clear and concise reports that are capable of being automatically inserted into the control files; reported information is also easily inserted manually into systems control records to update the information contained in them. However, its control programs and user, system, and circuit designators are designed to be applied to a multi-service world-wide communications network rather than a tactical communications system.

From the foregoing discussion it can be seen that none of the present methods for communications systems control meet all of the criteria which an adequate systems control doctrine must satisfy. Chapter VI presents a proposed doctrine for field army communications systems control which fulfills all requirements. Its procedures are simple, concise, and effective; it retains desirable elements of previous systems control methods and proposes new techniques and concepts for those areas where previous

procedures have been found to be inadequate. It is equally adaptable to either manual or automated systems control operations.

CHAPTER VI

A PROPOSED DOCTRINE FOR FIELD ARMY COMMUNICATIONS SYSTEMS CONTROL

Field army communications systems control is the day-to-day direction of communications facilities, systems, and personnel to achieve an integrated communications network that is swiftly and accurately responsive to the needs of its users. Systems control procedures must be clear, simple, and flexible. They must enable the controlling element to respond immediately and unerringly to any changes in the communications network which occur as a result of equipment failure, combat loss, interference with system operation, or degradation of circuit quality. Centralized control must be maintained to insure uniform and reliable communications support. Decentralized execution must be accomplished if prompt reaction to user needs is to be achieved.

Responsibility for Field Army Communications Systems Control

There are two supervisory elements of the field army which may logically exercise central control of the army communications network: the signal staff section of the army

headquarters and the operations staff section of the army signal brigade.

The army signal officer, as a member of the army special staff, is responsible to the army commander within his area of interest for the common staff functions of providing information, making estimates, making recommendations, preparing plans and orders, and supervising the execution of the commander's decision. The signal officer acts in the name of the army commander within the authority delegated to him. As an assistant to the commander he is concerned with the signal function as it affects the army as a whole.[1] In this capacity his communications control responsibilities include:

1. Frequency control and allocation.
2. Circuit allocation.
3. Establishment of priorities for signal support.
4. Signal planning in support of the army's mission.
5. Preparation of the signal annex to the army operations order.
6. Preparation and issue of standing signal instructions (SSI) and signal operating instructions (SOI).

The army signal brigade is provided within the field army structure to establish, operate, and maintain the army

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[1]U.S. Army Command and General Staff College, <u>Staff Organization and Procedures</u>, ST 101-5-1, (Fort Leavenworth, Kansas: April 1966), pp. 4-6, 20. (Fort Leavenworth, Kansas Library).

communications system.[2] All systems within the field army communications network are installed and operated by subordinate elements of the signal brigade. The brigade commander has no responsibilities for army signal functions outside his command. He is, however, the single manager of the field army communications network, and is responsible to the army commander for its proper functioning. The responsibility for systems control belongs to the signal brigade. To assign this function elsewhere is to violate the principle of mission-type orders by depriving the signal brigade commander of his prerogative to specify how the resources of his command will be used in the accomplishment of his mission. Since he is the sole operator of the field army communications system there is no need for the army signal officer to coordinate or direct the internal operations of the field army network or to retain any operational responsibility for communications systems.

Present organizational trends affecting larger units seem to indicate that the army signal brigade commander may soon be assigned the dual role of commander and army signal officer as a matter of policy. The commanding general of the 1st Signal Brigade in Vietnam also serves as the signal staff officer of U.S. Army Vietnam; the commanding officer of Strategic Army Communications Command (STRATCOM) Pacific is also the assistant chief of staff for communications-

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[2] See above, p. 58.

electronics, U.S. Army Pacific.[3] The division signal officer has been both a commander and a division staff officer for many years. A discussion of the desirability of this step lies outside the scope of this work. It must be re-emphasized, however, that the systems control function within the field army is properly the responsibility of the signal brigade commander.

Organization for Systems Control

To enable the signal brigade commander to carry out his communications control functions he establishes an operations section within his staff. Organization of this section will depend in large part on the current activities of the signal brigade, the desires of the commander, and the preferences of the brigade S-3. The chart shown in Figure 11 is offered as a guide. Common administrative services for the operations section are provided by the administration division. Plans for the employment of the signal brigade in support of current and future field army operations are prepared and maintained by the plans division, which is also responsible for recommendations concerning the routine displacement of signal centers and the establishment of facilities communications. Matters dealing with the

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[3] "Consolidation Move: STRATCOM Adds Viet Signal Brigade," Army Times, XXVI, 39 (11 May 1966), p. 11.
"Army Enlarges STRATCOM's Role in Pacific," Army Times, XXVII, 15 (23 November 1966), p. 39.

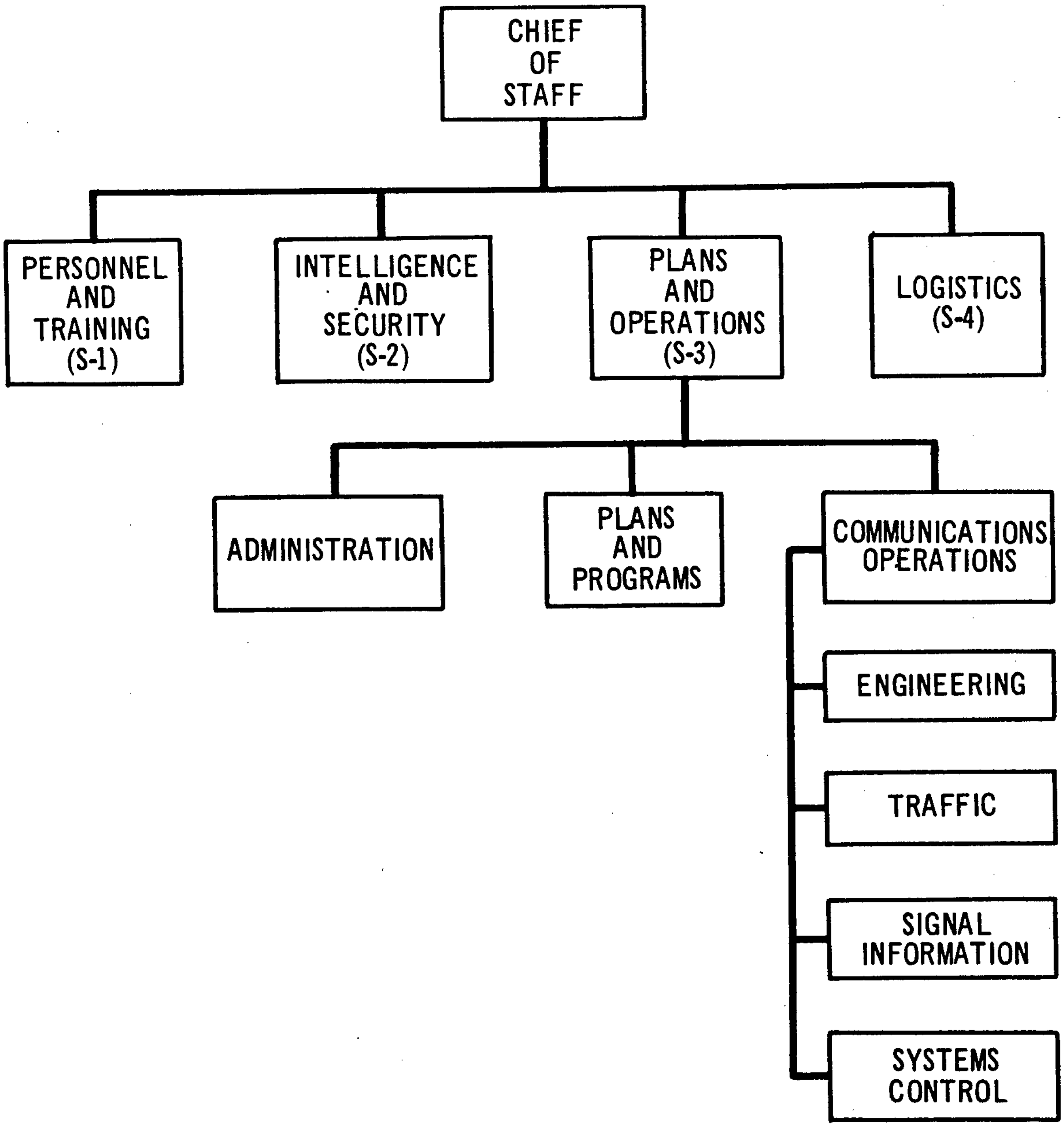

Figure 11. Proposed Staff Organization for Operations.
Field Army Signal Brigade

technical aspects of brigade operations are the responsibility of the communications division. The last-named division has four branches: the engineering branch, to carry out systems and circuit engineering; the traffic branch, which analyzes traffic data and recommends circuit changes as necessary; the signal information branch, responsible for the operation of the signal information service; and the systems control branch, which provides technical direction for the subordinate operating elements of the signal brigade.

The specific functions of the systems control branch are to:

1. Establish a main systems control center near or within the army main headquarters and an alternate systems control center near or within the army alternate headquarters.

2. Develop and publish standing operating procedures for status reporting, installation, routing, test, and maintenance of communications facilities, systems, and circuits.

3. Inspect operational systems and facilities to insure compliance with standing operating procedures and inform the commander and staff of the results of these inspections.

4. Maintain current information about the status of signal units, equipment, and operating personnel.

5. Inform the commander and staff of the signal brigade about the current signal status as directed.

6. Recommend to the signal brigade S-3 those signal centers to be established or displaced in the event of combat loss or natural disaster which disrupt the operation of the field army communications network.

7. Coordinate the operations of the field army signal messenger service.

All technical instructions or requests for information emanating from other staff branches or divisions are passed to the control branch for transmission over the sole-user control network to the operations section of subordinate signal battalions. This section functions as a systems control center with responsibility for subordinate signal companies. It assists the signal battalion commander and the signal brigade systems control branch by:

1. Maintaining systems control records for the portion of the army communications network installed and operated by the signal battalion.

2. Supervising the execution of communications orders.

3. Assisting in the rapid restoration of signal centers, systems, and circuits within its capabilities.

4. Informing the battalion commander of the status of his command.

5. Evaluating the extent and nature of damage to signal centers or facilities in the event of combat loss or natural disaster, reporting the situation to the signal

brigade systems control branch, and recommending actions to be taken to restore communications.

The battalion complies with the directive, if within its capabilities to do so, or issues instructions to its subordinate companies for the necessary action. It reports to the control branch when the instructions have been complied with.

Communications Designators

Communications designators are symbols which identify users of the army communications system. Their use aids in preparing systems and circuit designators, records, and reports, and facilitates positive direction of the operating elements when establishing systems, circuits, and messenger service. Communications designators should be as concise as possible and easy to remember. A sufficient number must be provided to permit assignment to all users.

Within the type field army there is a total of approximately 1,350 headquarters which may require signal support from the army network at some time. Other headquarters such as those of theater army, adjacent armies, and elements of other services will also be connected into the army communications system. Since it is impossible to determine beforehand which units will require signal support in any given situation it is necessary to assign a communications designator to all assigned or attached units of the

field army; to external headquarters, units, or agencies provided access to the field army network; to all signal centers; and to all field army elements which require sole-user circuits routed over the army communications system.

Headquarters, units, or agencies which terminate circuits are assigned a three-character communications designator consisting of two numbers and a letter. This combination provides a total of 2,600 designators from 00A to 99Z, an ample number for field army requirements. Signal centers and control centers are assigned a two-letter communications designator. Blocks of communications designators are reserved for different categories of users or signal centers as shown in Table 2.

System Designators

A system designator is provided for each multichannel system installed, whether telephone or teletypewriter. The following method provides system designators that are concise, easily remembered, and that convey adequate information for control purposes about the system type, location and capability.

The system designator is composed of the communications designators of the connected signal centers, followed by a two-digit number giving the number of channels in the system, a letter showing the transmission medium, and a one-digit number indicating the first, second, etc. system established between the two locations. A list of

TABLE 2

ASSIGNMENT OF COMMUNICATIONS DESIGNATORS

Using Element	Communications Designator Block	Example	
		User	Communications Designator
Headquarters, army units, etc.	11A-89Z	30th Engineer Brigade	25K
External users	9Ø-99Z	Theater Army	9ØA
Sole-user terminals	ØØA-Ø9Z	Alternate FATOC	ØØB
Command signal centers	AA-AZ	Army headquarters	AA
Control centers	QA-QZ	20th Signal Brigade Systems Control Center	QA
Area signal centers	RA-SZ	796th Signal Company (Army Area)	RP

appropriate symbols to indicate the transmission medium is given in the Appendix. The initial communications designator is that of the signal center having responsibility for test and alignment of the system. For example, a twenty-four-channel tropospheric scatter system between army headquarters and corps headquarters might be designated AAAF24T1; a forty-eight-channel system between two area signal centers might receive systems designator RARE48V1. The same method is followed for teletypewriter systems.

The possibility of confusion between telephone and teletypewriter systems established between the same locations is eliminated by the fact that the present and future field army telephone carrier equipments (AN/TCC-7, AN/TCC-60, AN/TCC-63, etc.) provide systems with multiples of twelve channels; tactical teletypewriter carrier equipment provides four, eight, or sixteen channels. The system ABRH08V1 can only be a teletypewriter system. Some lower-echelon tactical units such as the airborne division have four-channel telephone carrier equipment (AN/TCC-3). In the unlikely event that equipment of this type is made available to the field army for use in the army network, the number of channels will be shown as T4 to indicate a four-channel telephone system; for example, RARCT4V1.

Circuit Designators

Each circuit within the field army must be identified to provide a means for routing, rerouting, and prompt restoral in the event of system or signal center failure.

The circuit designator consists of a combination of eight to ten characters composed of the communications designators of the terminal locations and a four-digit circuit number. Teletypewriter circuits are numbered from 0001 to 0999, telephone circuits from 1000 to 9999. This method of constructing circuit designators permits quick identification of telephone or teletypewriter sole-user circuits, tributary trunks, and long-distance trunks. For

example, circuit 00A00C0154 is identifiable as a sole-user teletypewriter circuit, since communications designators beginning with 0 are reserved for sole-user terminals and circuit numbers beginning with 0 are assigned to teletypewriter circuits. Circuit designator AB11C1042 identifies a tributary trunk connecting signal center AB with user 11C. Circuit RARD1975 is a long-distance trunk between the two signal centers RA and RD. Direct trunks between two unit switchboards may also be identified, as in the case of circuit 51D42P2638.

The Signal Information Service

The signal information service is responsible for providing up-to-date information about all units which are served by the army communications network. This information includes the geographical location of the unit, its supporting signal center, and routes to be followed in passing telephone calls, teletypewriter messages, and data and facsimile transmissions to the unit with maximum speed of service.[4] Almost all of these facts are obtained from the operating signal centers by means of reports submitted over the sole-user control network. The signal centers, in turn, are major users of this information when compiled and returned to them in the form of route bulletins and traffic diagrams.

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[4]U.S. Department of the Army, Tactical Communication Systems, Army, Corps, and Division, FM 11-21, (Washington: U.S. Government Printing Office, November 1961), pp. 49-52.

The basic record of the signal information service is the unit file, which is maintained in card format to permit arrangement of the file for maximum efficiency, allow changes, insertions, and deletions to be made promptly, and provide a means of converting the file to automated methods with a minimum of effort. A unit locator card is prepared for each element of the field army which is assigned a communications designator. In addition to the communications designator, the unit locator card records the telephone directory name (if applicable), the communications designator of the supporting signal center, the unit name, the unit location in six-digit coordinates, the teletypewriter routing indicator, and the date-time group that the entry was made. The unit file is used to prepare route bulletins or locator registers by arranging the unit record cards in order according to unit name or telephone directory name. After initial distribution has been made changes can be transmitted to using units over the control network. An example of a unit locator card is shown in Figure 12.

Systems Control Records

To enable the systems control element to control effectively the activities of the operating units, information must be readily available about the users of the communications network, its operational status, and its capabilities for expansion to meet additional demands for communications

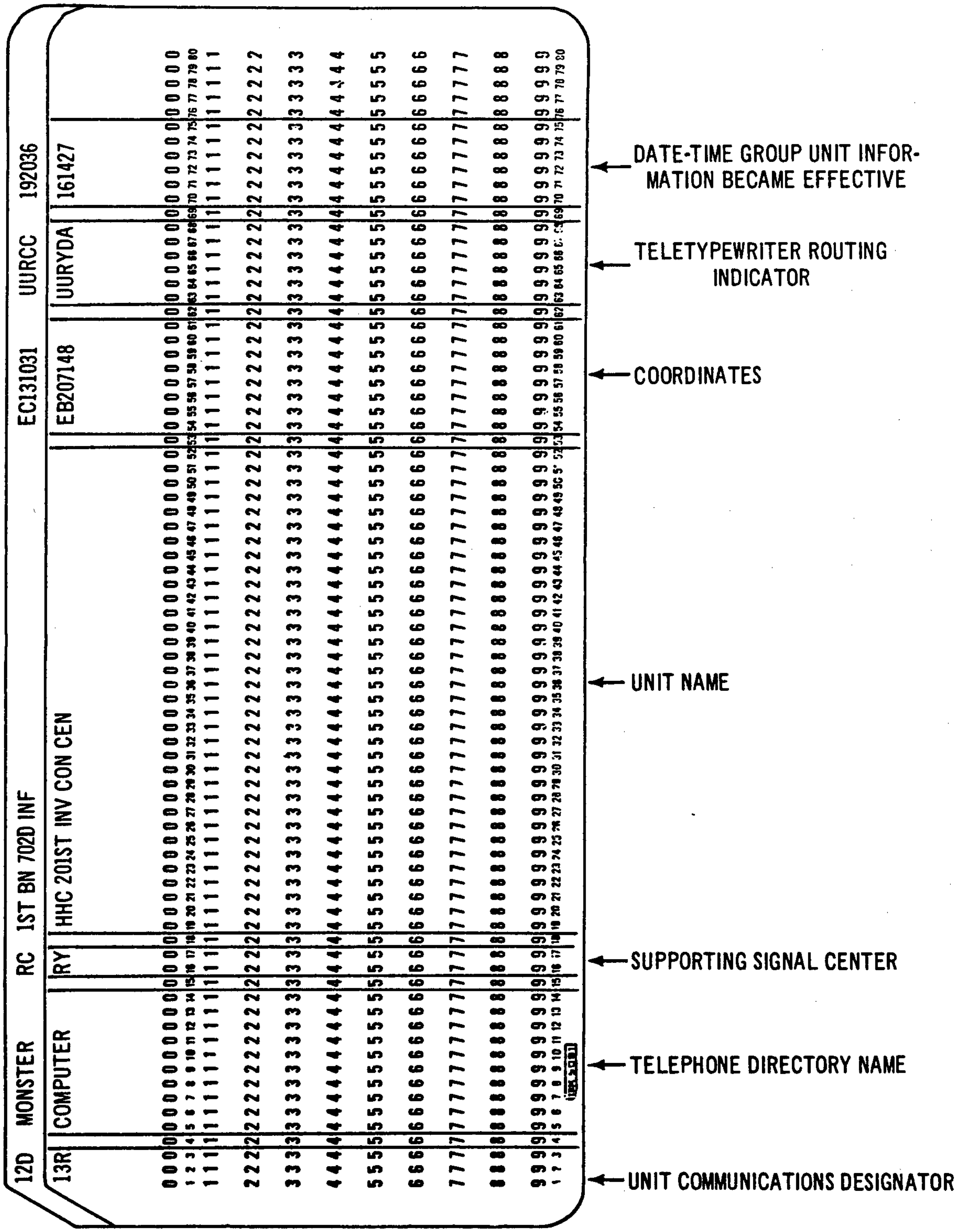

Figure 12.--Examples of Unit Locator Cards.

support. The following records are the minimum required for effective control of the army communication system.

Signal Situation Map

The signal situation map presents a graphic portrayal of the current status and location of friendly units, signal centers, and other signal operating elements such as radio relay repeater stations and test points. All signal staff sections and control centers should maintain a situation map, preferably in the form of an acetate overlay with information entered in grease pencil to facilitate changes. The amount of information shown will depend on the echelon and the function of the section maintaining the map. Information of the type found in line route maps, radio relay systems maps, and systems diagrams may be included.

Systems Diagram

The systems diagram for a particular operation is prepared by the plans division of the signal brigade staff and is included as an annex to the signal brigade operations order. When changes occur new systems diagrams will be prepared and distributed to the other sections of the brigade staff and to the operating elements.[5]

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[5]See above, Fig. 6, p. 76.

Radio Relay Systems Map

The radio relay systems map is prepared in map overlay form by the engineering branch of the communications division. It is included as an annex to the signal brigade operations order. New overlays are prepared and distributed as changes occur.[6]

Radio Net Diagram

Radio net diagrams are used at all echelons throughout the field army. The signal brigade only concerns itself with those radio nets operated by its subordinate units. These include the various army command, logistics, and intelligence nets and the signal brigade command and control nets. The radio net diagrams for army nets are published by the army signal officer's section. They may be included in the army standing operating procedure (SOP) or attached to the signal annex of the army operations order. Radio net diagrams for the signal brigade nets are prepared by the plans division and will normally be included in the brigade SOP. Frequency assignments are listed in the army signal operating instructions (SOI).

Traffic Diagrams

Three types of traffic diagrams are utilized within the army communications network.

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[6]See above, Fig. 7, p. 77.

<u>Sole-user traffic diagram</u>.--The army sole-user traffic diagram is prepared by the army signal section, which determines those field army users requiring sole-user circuits and the number required. It is included in the signal portion of the army SOP. Circuit designators for these circuits are assigned by the control branch of the signal brigade staff and appear in the diagram when prepared in final form. This record indicates to subscribers their authorization for sole-user circuits and provides a visual reference for systems control centers in issuing circuit orders.

<u>Telephone traffic diagram</u>.--This diagram is prepared by the traffic branch of the signal brigade staff and issued to all signal centers.[7]

<u>Teletypewriter traffic diagram</u>.--The telephone traffic diagram is prepared by the traffic branch of the signal brigade staff. It shows the number of common-user teletypewriter trunks established in the army communications network. It is distributed to all signal centers for use by teletypewriter exchange operators and communications center supervisors in routing teletypewriter traffic.

Unit File

The unit file is discussed under the heading of the signal information service.[8]

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[7]See above, n. 11, p. 71 and Fig. 4, p. 72.

[8]See above, p. 125.

Telephone Route Bulletin

The telephone route bulletin is prepared from the unit file by the signal information branch of the signal brigade staff. It lists the units of the field army by their telephone directory code name and gives the communications designator and telephone code name of the signal center supporting the unit. In conjunction with the telephone traffic diagram it provides telephone switchboard operators with information necessary to route calls.

Signal Center File

The signal center file is maintained in card format by the control branch. A card is prepared for each signal center, listing the communications designator of the signal center and equipment in use, spare, and deadlined by type number.

Circuit Requirements File

The circuit requirements file is prepared in card format by the traffic branch of the signal brigade staff and updated when circuit allocations are approved by the army signal officer, based upon changes in unit assignments or analysis of traffic data. Listings and changes are furnished to the control branch for use in issuing communications orders and insuring that user needs are met. A circuit requirements card is prepared for each unit listed in the unit file. It lists the communications designator of

the unit, the number of tributary trunks required, and direct trunks and sole-user circuit requirements by circuit designator. In manual control operation only one card is necessary; for automated operation additional cards may be required. An example of a circuit requirements card is shown in Figure 13.

System File

The system file is prepared and maintained in card format by the control branch. For automated systems control a system header card, several system channel cards, and a system trailer card are required. The system header card contains the system designator and the type of terminal equipment employed. The system channel card is prepared for each channel in the system. It lists the system designator, the channel number, and the circuit designator and priority of the circuit utilizing the channel. Information about the radio path, including terminal locations, elevations, frequencies, power output (applicable to high-frequency systems), and antenna orientation are listed on the systems trailer card. Examples of systems header, channel, and trailer cards are shown in Figures 14, 15, and 16. In manual systems control operation this information can be kept on one card.

Circuit Register

The circuit register is a listing of all circuit in numerical order by circuit number (the last four digits

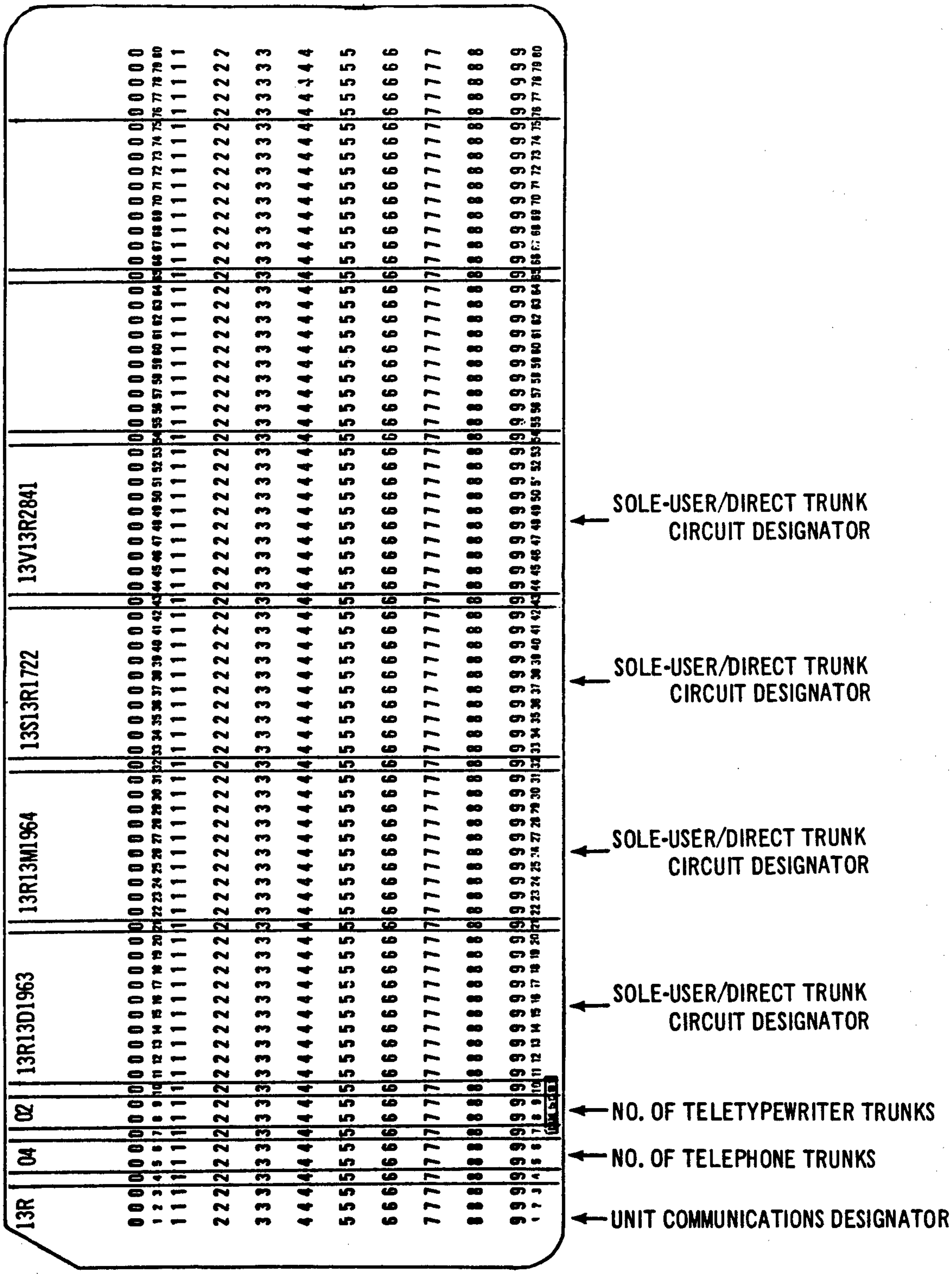

Figure 13.--Example of a Circuit Requirements Card.

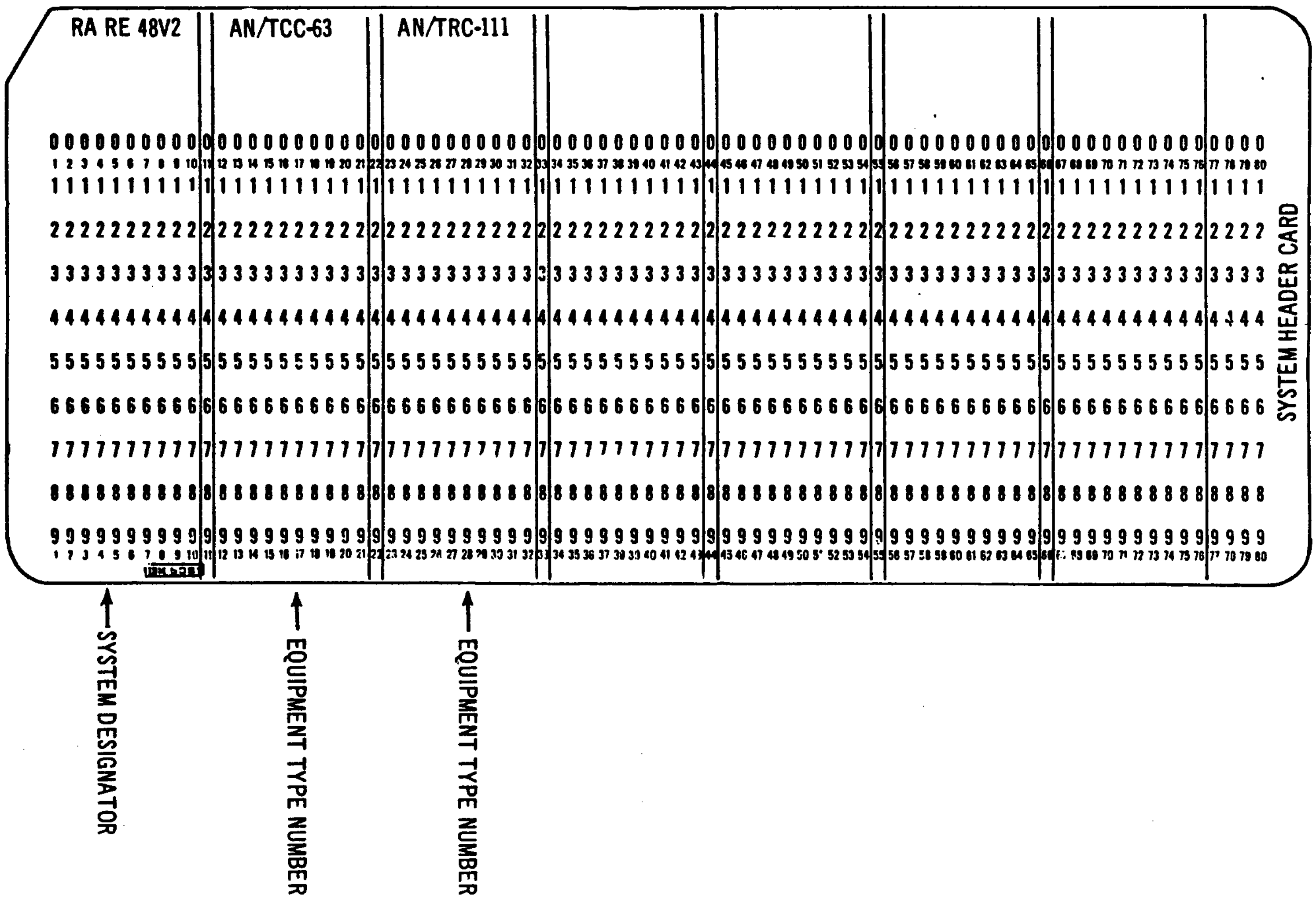

Figure 14.--Example of a System Header Card

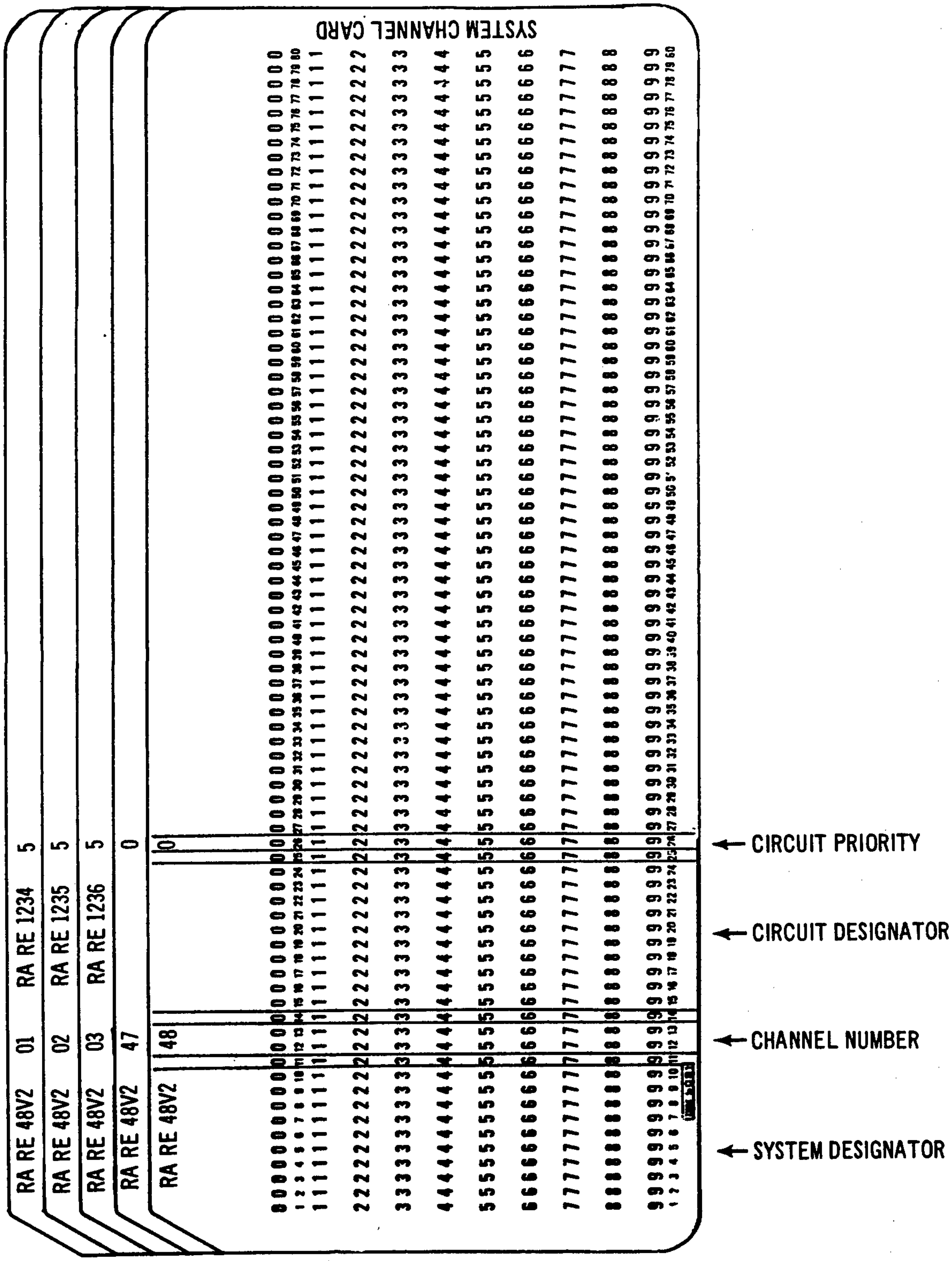

Figure 15.--Examples of System Channel Cards

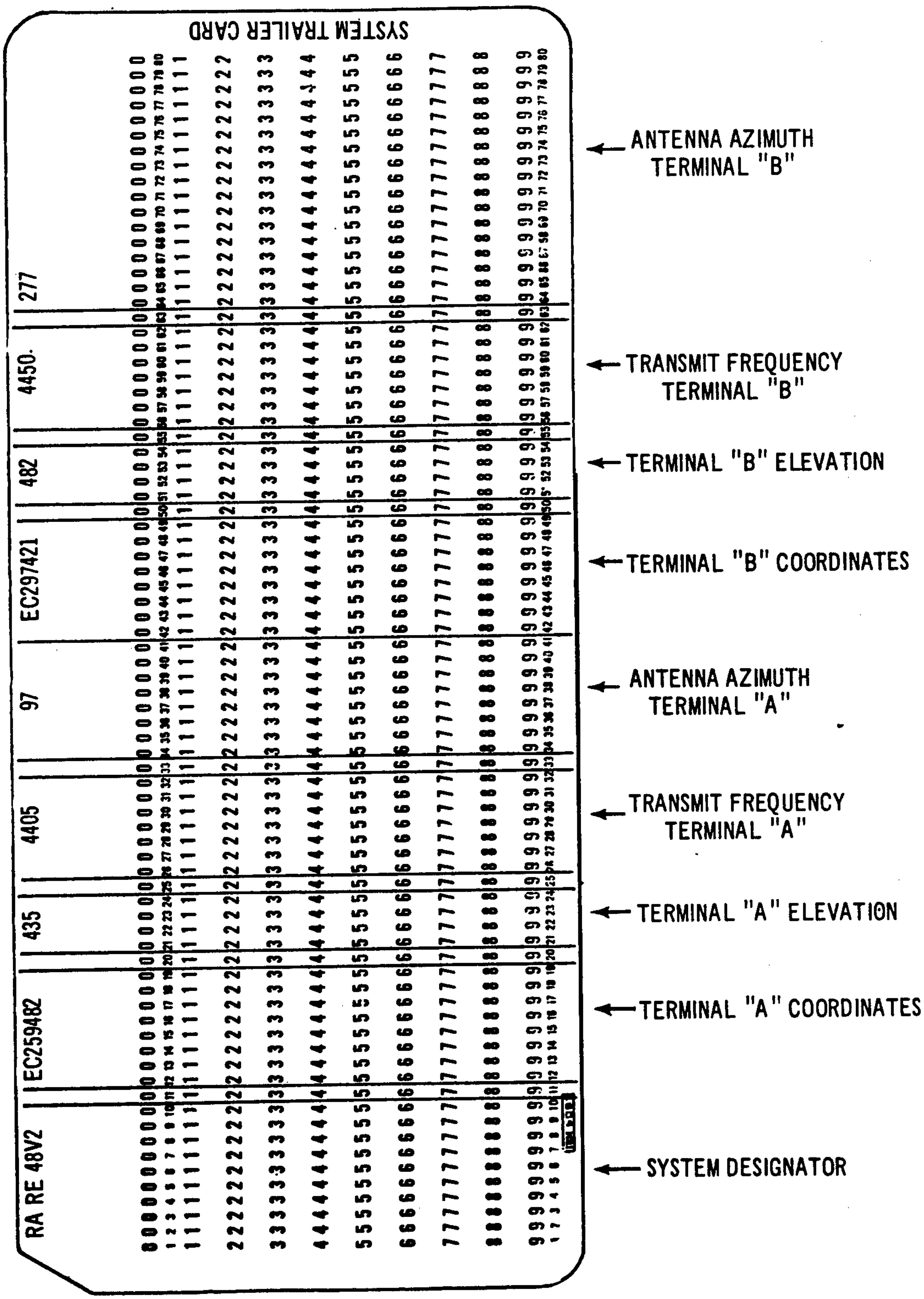

Figure 16.--Example of a System Trailer Card

of the circuit designator). The register contains the circuit designator, the type of circuit (telephone, teletypewriter, etc.), and the date the circuit was activated. It is prepared by the control branch to insure that circuit numbers are not duplicated. In automated systems control operation this information can be obtained from the circuit record file by sorting the circuit record cards according to the circuit number and listing the results; a separate circuit register need not be maintained.

Circuit File

The circuit file is prepared and maintained in card format by the control branch of the signal brigade staff. The circuit card contains:

1. The circuit designator (ten characters). Circuits terminated at a signal center will have a blank following the signal center communications designator. For example: circuit RA RE 2751; circuit RA 2533519.

2. The segment number (two digits.)[9]

3. The system designator of the system providing the segment (ten characters).

4. The channel number of the system providing the segment (two digits).

---

[9]A segment number is assigned to each portion of the circuit between two terminals where the circuit may be entered, terminated, or rerouted. Segments are numbered consecutively from one terminal instrument to the other. A circuit card is prepared for each segment of the circuit.

5. The type of operation of the circuit (a one-character code).[10] A list of appropriate symbols is shown in the Appendix.

6. Circuit priority (one digit). Six priorities are established:

Priority 0. Spare channels (used in system channel card).[11]

Priority 1. Systems control circuits and signal engineering and order wire circuits.

Priority 2. Command and control sole-user circuits.

Priority 3. Movements control, artillery direction, and logistical sole-user circuits.

Priority 4. Command common-user circuits, i.e. direct trunks between command signal centers.

Priority 5. All other circuits.

7. Type of security equipment used on the circuit (four characters).

8. Teletypewriter system designator, if the circuit is used to route a teletypewriter system (ten characters).

---

[10]The type of operation code indicates the type of terminal instruments used on the circuit, such as telephone, teletypewriter, data, facsimile, etc. A separate symbol should be assigned for each type of operation utilized within the field army network, e.g., sixty word-per-minute teletypewriter, sixty-six word-per-minute teletypewriter, five card-per-minute data, etc.

[11]See above, p. 131.

An example of an automated circuit card is shown in Figure 17. In manual operation all circuit segments will be listed on the same card.

Communications Reports

In order for the control branch to maintain up-to-date information about the status of the army communications system the operating elements are required to submit reports through the operations section of their controlling battalions to the brigade systems control. Reports are required whenever a system or circuit has been out of operation for more than fifteen minutes, when action is taken to establish or discontinue a circuit, when a subscriber relocates, or when a signal center has untransmitted messages which cannot be transmitted within the time allowed for the precedence of the message. This information should be submitted as reportable events occur, but in no case more than three hours after the event. Reports will normally be submitted over the systems control sole-user network; in an emergency the telephone or any other available means will be used. A daily status report will be submitted as of 2400 hours local time summarizing the operational capabilities of each signal center and providing a summary of traffic handled during the previous day. Reports will be numbered consecutively beginning with number one at the start of each day.

Reports will be prepared in teletypewriter message format. The message heading will contain the call sign or

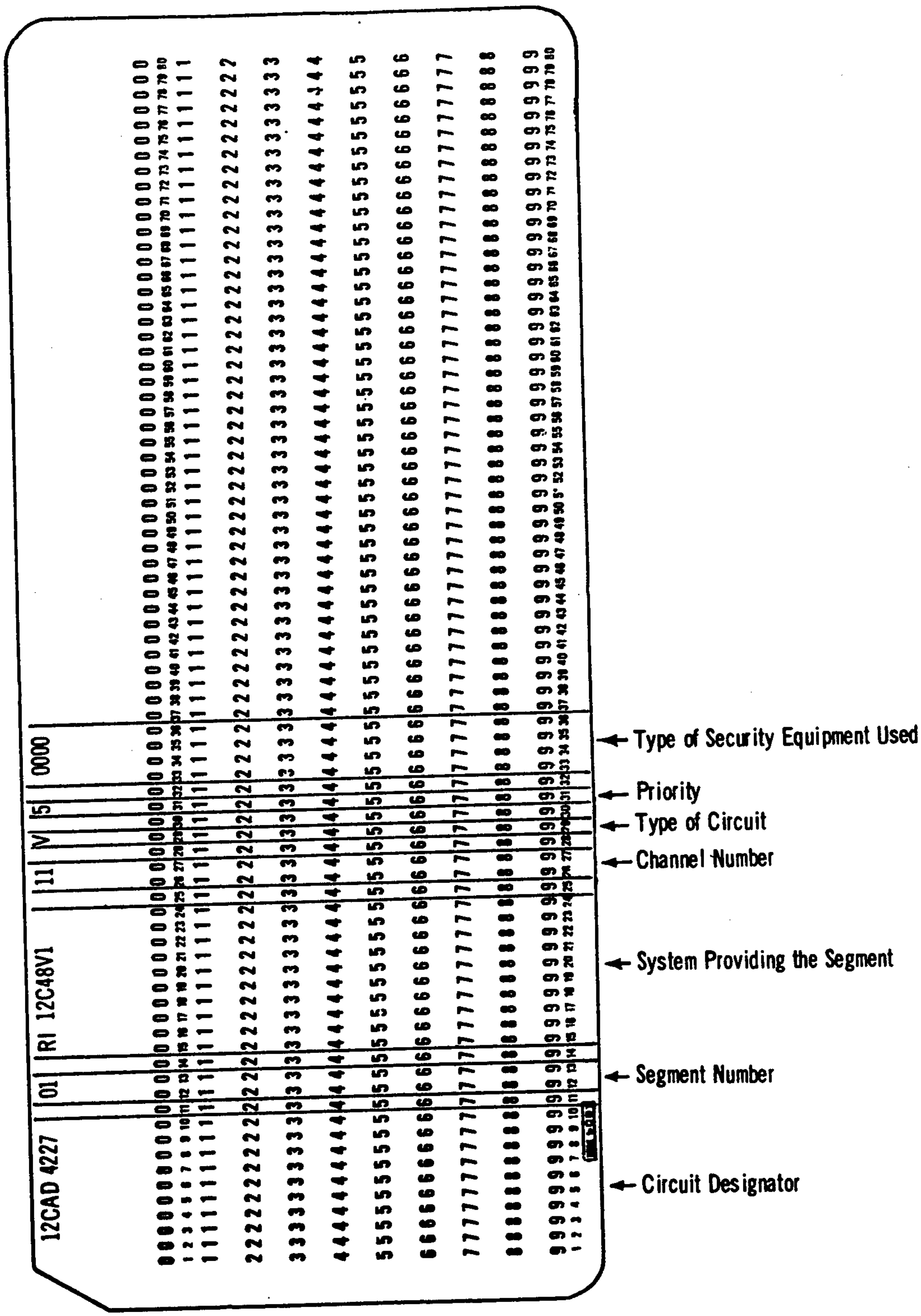

Figure 17.--Example of a Circuit Card

routing indicator of the addressee and the sending signal center, the precedence of the message, and message handling instructions if required. The body of the report will refer to a communications order if the report announces completion of the action directed by the order. Information will be submitted using an eight-line format as follows:

1. O-line "operator." This line gives the communications designator of the reporting signal center, the time of the report, and the report number.

2. T-line "traffic." This line is used to report traffic information. It lists the communications designator of the connected signal center and the amount and type of traffic transmitted or awaiting transmission by message precedence.

3. U-line "user." This line reports the relocation of using units. It lists the communications designator of the user, the telephone directory name, the old and the new coordinates of the user's location, and the time the unit departed or arrived. Only the new coordinates and time of arrival are required to be reported when a unit arrives in a signal center's area of responsibility.

4. S-line "systems." This line reports system failure, restoral, activation, or discontinuance. It includes the system designator, channel number (if applicable), time of the reported event, and the reason for failure (outage). An appropriate three-character reason-for-outage code is given in the Appendix.

5. A-line "allocation." This line is used to show a change in the use of a channel. It informs the signal control center that a circuit has been restored by using a channel previously assigned to a lower-priority circuit. The line includes the system designator and channel number of the system used to reroute the higher priority circuit, the circuit designator of the rerouted circuit, and the time of the event.

6. C-line "circuits." This line provides information about circuit failure, restoral, activation, or discontinuance. It includes the circuit designator, the segment number, the system designator of the system providing the segment, the channel number, type of operation, the time and nature of the event, and the reason for outage.

7. E-line "equipment." This line is used in daily status reports to show the status of equipment in the reporting signal center. It gives the type number of selected types of equipment and the number of these items in use, spare, and deadlined.

8. D-line "date." This line gives the actual date and time the report was prepared.

Information not available to the reporting signal center will be shown by the letter "X" in the appropriate line and position.

The sequence of lines indicated above must be followed, but not all lines are necessary to complete a report. The C- and the D-lines are mandatory; the other

lines are included as necessary to list all reportable information. For example, a daily status report would only have an O, a T, an E, and a D-line; a report of user relocation would only include the O, U, and D-lines. A report may include as many T, U, S, A, or C-lines as necessary.

In automated systems control procedures the report format must be modified to provide the necessary machine instructions for automatic processing of the report and updating of records.

In all cases narrative remarks may be included following the last format line of the report.

Communication Orders

Communication orders are fragmentary orders which supplement the signal brigade operations order. They are issued by the control branch to subordinate battalions in the name of the brigade commander within the scope of the authority delegated by him. The battalions accomplish the necessary action if within their capabilities or transmit the order to their subordinate companies for action. In an emergency, communication orders may be issued directly to the operating companies, with the controlling battalion headquarters notified of their contents as soon as possible.

Communication orders will be numbered in sequence throughout the calendar year, will contain a reference to

the effective signal brigade operations order, and will be clear and concise to insure prompt understanding and speedy accomplishment of the necessary action. The words "activate," "discontinue," "establish," etc. followed by appropriate extracts from the system file or the circuit file may be used to meet the requirements for simplicity and brevity.

Circuit Requests

Circuit allocations to using units will normally be made by the army signal officer, published in the signal portion of the army SOP, and included in the circuit requirements file. The traffic branch of the communications division will propose changes in allocation to the signal brigade S-3, based upon a statistical analysis of traffic information received from the operating signal units. These recommendations will be coordinated with the army signal officer; upon his approval they will be included in the signal portion of the army SOP and the circuit requirements file will be updated.

Whenever a unit feels that it requires additional circuits to support its mission it will submit a circuit request to the traffic branch justifying its additional requirements. The traffic branch will compare the request with the traffic data pertaining to the unit, and will attach its comments and recommendations to the request. The request will be forwarded for consideration by the signal brigade S-3 and the army signal officer. The army

signal officer will inform the unit and the traffic branch of the action to be taken. If he approves the request he will make the necessary changes to the signal portion of the army SOP. The traffic branch, in turn, will update the circuit requirements file.

Summary

The proposed doctrine outlined in this chapter is applicable to both manual and automated systems control methods. It establishes and defines the responsibilities for the various actions necessary to accomplish effective control of the army communications network. Its procedures are simple and flexible, providing a concise system of records, reports, and orders. It appears to be an adequate solution for a difficult problem.

In order to determine the ability of this proposed method to react promptly and effectively to the ever-changing aspects of combat, it must be tested and examined in various situations to insure its adequacy. In the following pages a portion of a large-land-mass field army communications network is developed and deployed. The proposed doctrine is applied to several contingencies which will adversely affect the performance of the army communications network.

CHAPTER VII

A TEST OF THE PROPOSED DOCTRINE

A portion of the field army command and area communications system is outlined in the following pages. It includes the various types of equipment found in the army communications network and a typical signal command and control structure. Situations which affect communications support are evolved and systems control actions required to restore communications are formulated by applying the manual control doctrine proposed in Chapter VI.

General Situation

The 30th (US) Army, a part of a joint US-Allied command, has been attacking to the east against stubborn Aggressor resistance with the mission of clearing Aggressor forces from its zone and securing Central City, a major communications center. By 1 September 196_, 30th Army was forced to halt temporarily and defend along the Green River due to combat service support difficulties. The 1st, 2d, and 3d (US) Corps are presently disposed along the Green River from north to south. By 22 September 196_ 30th Army expects to resume the offensive. A partial troop list for 30th Army is given in Table 3.

TABLE 3

PARTIAL TROOP LIST, 30th ARMY

Controlling Headquarters	Organization
30th Army (Army Troops)	26th Armored Division 201st Armored Cavalry Regiment 43d Artillery Brigade (AD) 50th Engineer Brigade (Cbt)(Army) 20th Signal Brigade (Army) 30th Chemical Group * * *
1st Corps	* * *
2d Corps	19th Infantry Division 52d Mechanized Division 53d Mechanized Division 23d Armored Division 312th Mechanized Brigade 202d Armored Cavalry Regiment 102d Aviation Group 402d Artillery Group (AD) 2d Corps Artillery 52d Engineer Brigade (Cbt)(Corps) 702d Signal Battalion (Corps) * * *
3d Corps	* * *
30th Field Army Support Command (FASCOM)	80th Medical Brigade 90th Ordnance Brigade (Ammo) 40th Transportation Brigade 20th Military Police Brigade 29th Civil Affairs Group 1st Support Brigade (Corps) 2d Support Brigade (Corps) 3d Support Brigade (Corps) 10th Support Brigade (Army) * * *

TABLE 3--Continued

Controlling Headquarters	Organization
20th Signal Brigade (Army)	21st Signal Group (Army)
	703d Signal Battalion (Comd Rad & Cable)
	708th Signal Battalion (Army Area)
	709th Signal Battalion (Army Area)
	710th Signal Battalion (CO)
	22d Signal Group (Army)
	704th Signal Battalion (Army Area)
	705th Signal Battalion (Army Area)
	706th Signal Battalion (Army Area)
	707th Signal Battalion (Army Area)

Special Situation

It is now 100800 September 196_. Elements of the 20th Signal Brigade (Army) are disposed as shown in Figure 18, a partial sketch of the signal situation map. Area signal centers RF, RG, and RL are controlled by the 704th Signal Battalion (Army Area); area signal centers RH, RI, RJ, and RM by the 705th Signal Battalion; and area signal centers RP, RK, and RQ by the 706th Signal Battalion. Command signal centers AA, AB, AD, and AE are controlled by the 703d Signal Battalion (Command Radio and Cable). Portions of the systems control network and the army systems diagram are shown in Figures 19 and 20. Extracts from the 30th Army unit file appear in Figure 21.

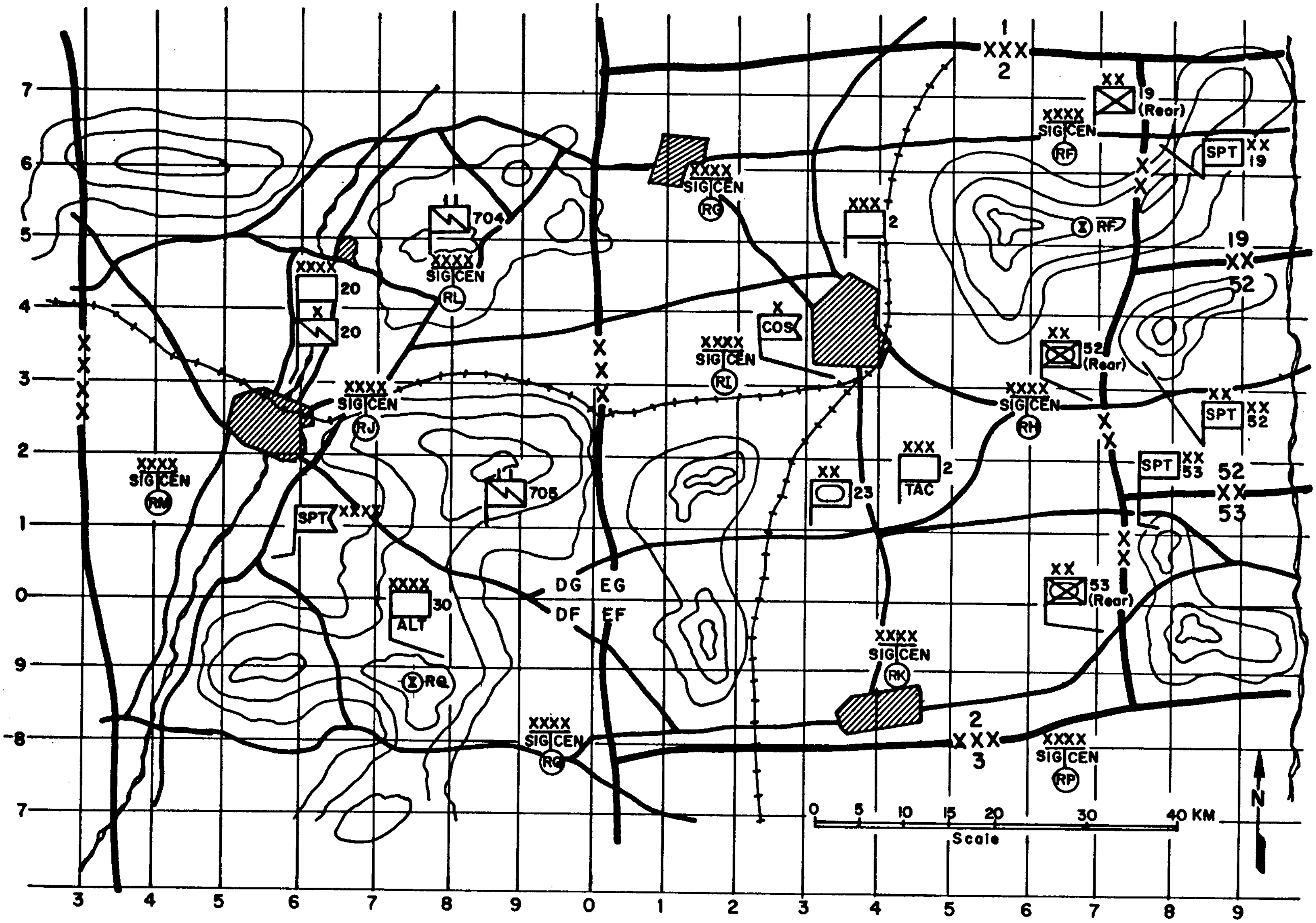

Figure 18.--Portion of the Signal Situation Map, 30th Army.

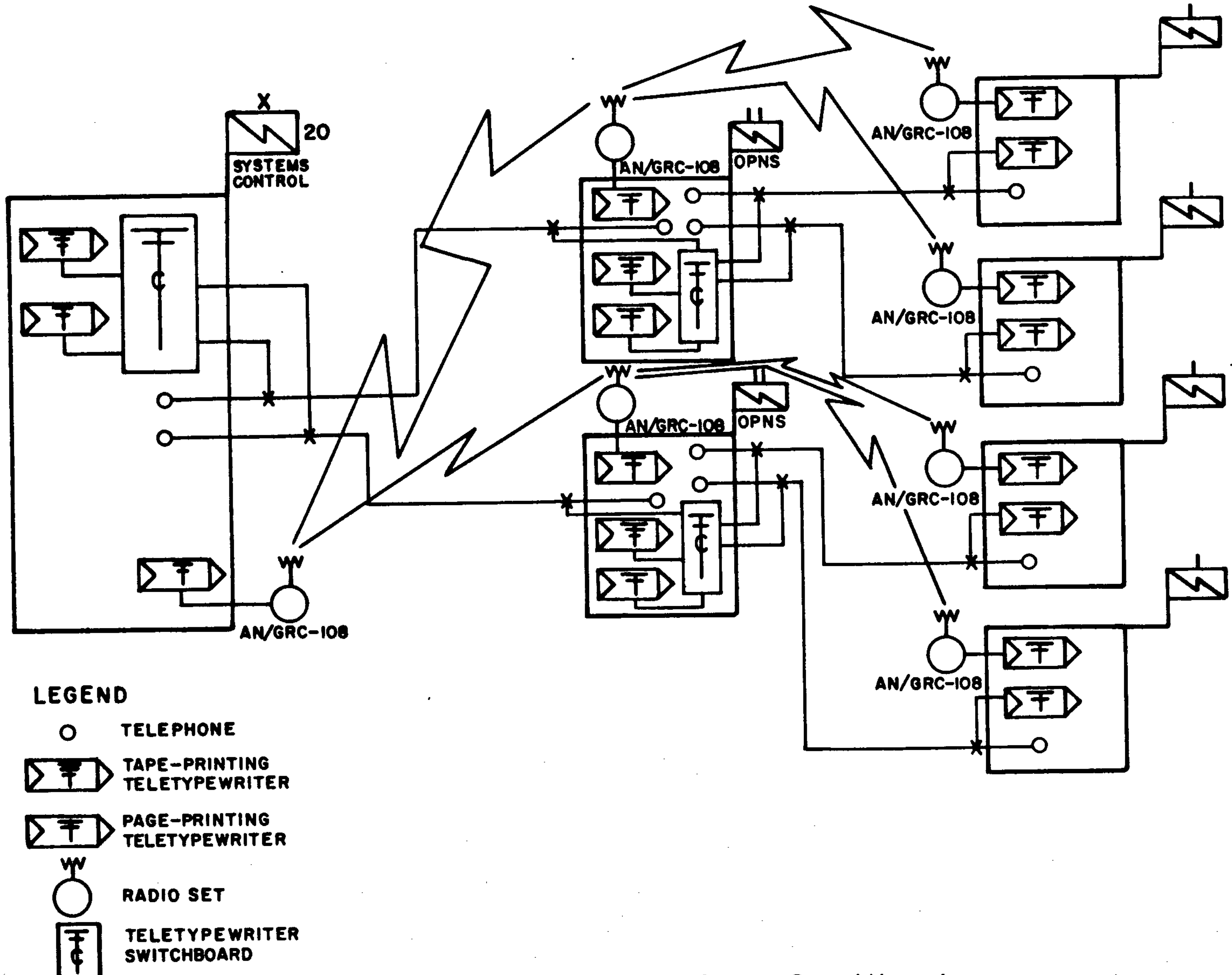

Figure 19.--Portion of the 20th Signal Brigade Systems Control Network

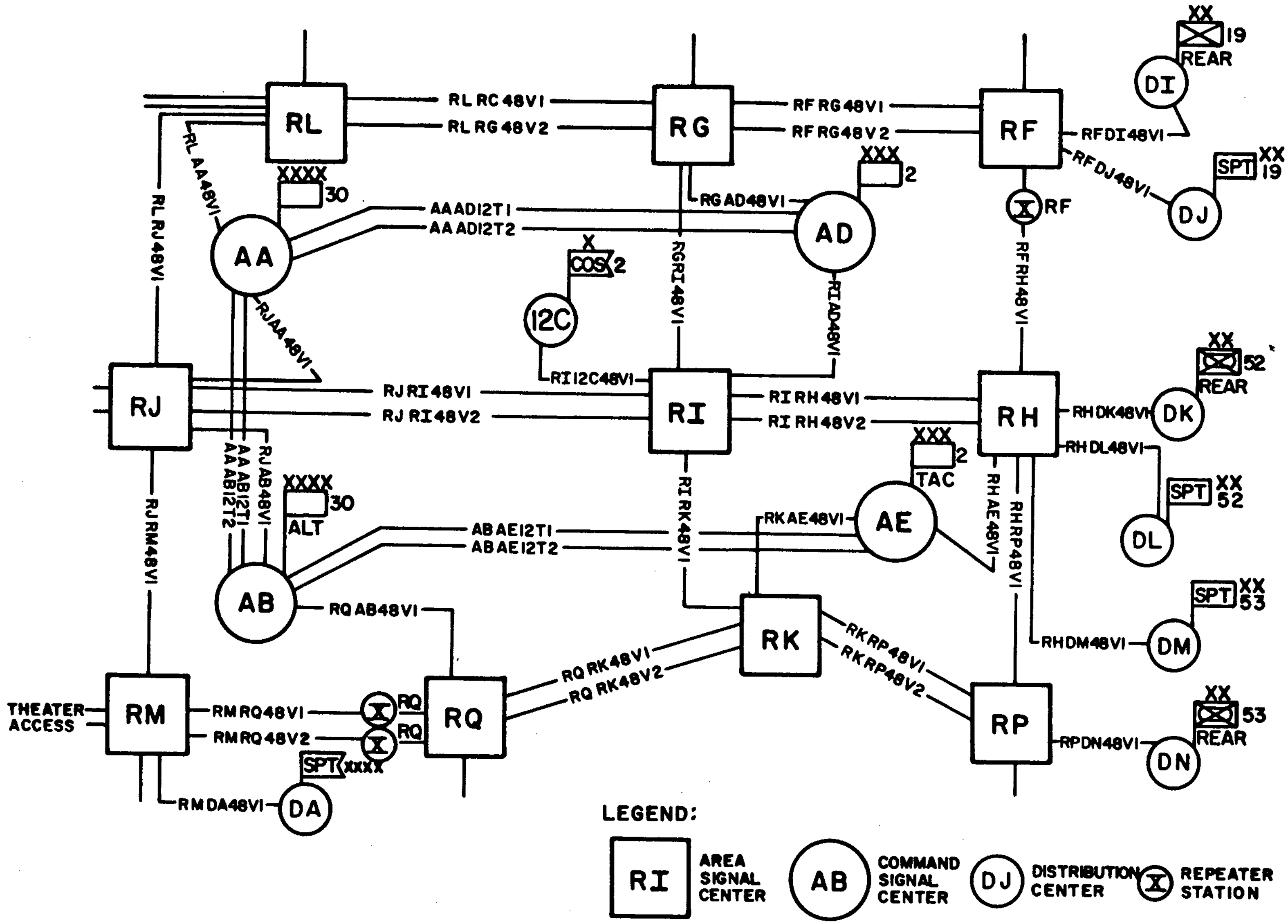

Figure 20.--Portion of the Systems Diagram, 30th Army

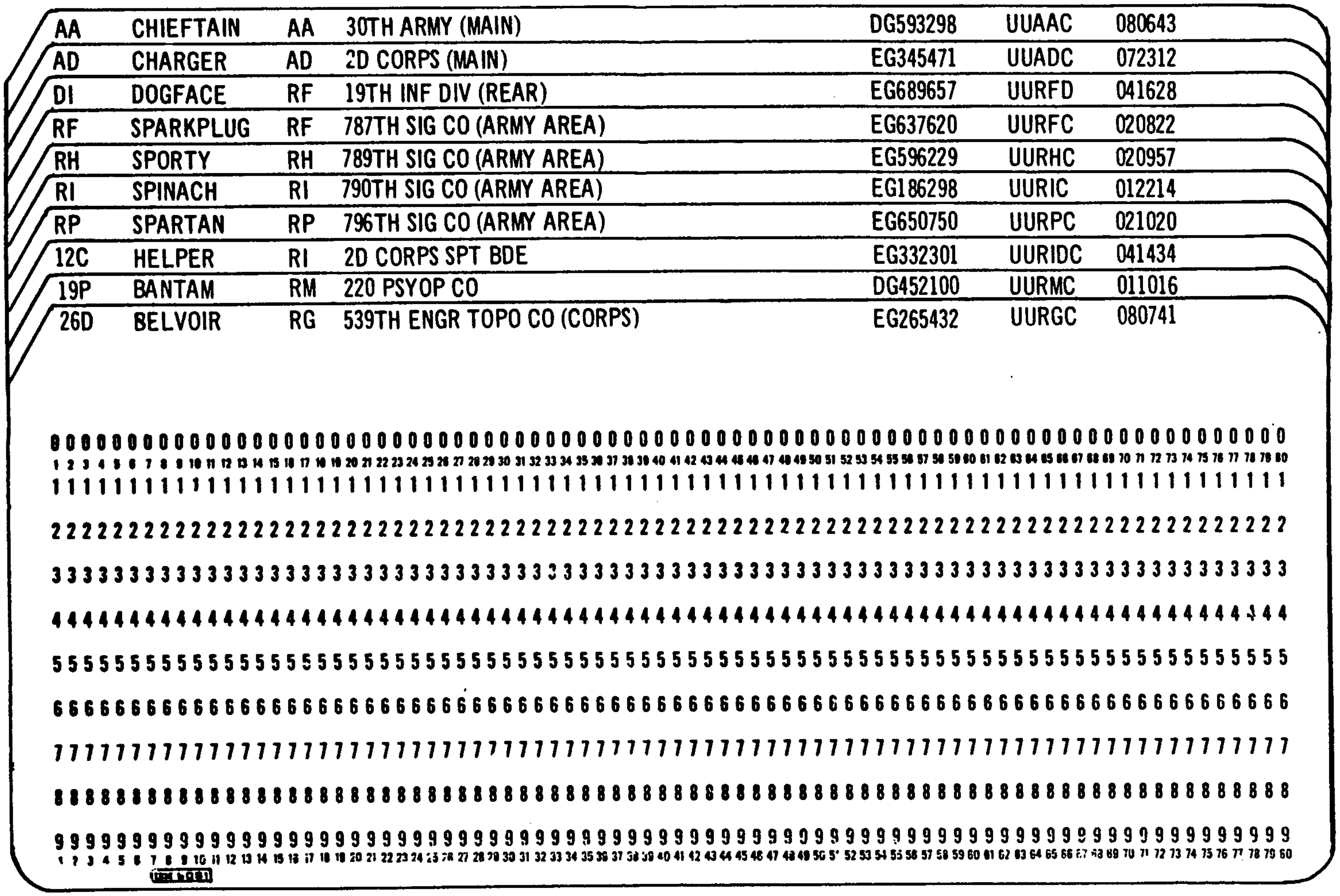

Figure 21.--Extracts from 30th Army Unit File

Examples of Systems Control Actions

Circuit or Channel Failure and Restoral

No action required by brigade systems control.-- The following report has just been received at the signal brigade systems control center:

```
    *     *     *
O/RF/1ØØ755/Ø2
S/RF DI 24C1/17/OUT1ØØ752/LVB
A/RF DI 48C1/23/RF DI 3426/1ØØ755
C/RF DI 3426/Ø1/RF DI 48C1/17/V/5/OUT1ØØ752/IN1ØØ755/
    LVG
D/1ØØ757
    *     *     *
```

This is a regular report announcing a circuit failure. The systems control action officer notes that the report is submitted by signal centers RF to inform him of an event occurring at 0755 hours. The "S" line shows that channel seventeen of system RFDI48C1 became inoperative at 0752. The cause of failure was trouble with the telephone carrier equipment at the relay terminal; the reporting signal center states that it does not require assistance to accomplish repair of the defective channel and will be able to do so within two hours (position three of the reason-for-outage code). From the "A" line the action officer sees that circuit RFDI3426 has been rerouted over channel twenty-three of system RFDI48C1. The circuit designator informs him that this is a common-user trunk between signal centers RF and DI; a glance at the systems diagram discloses that this is one of the trunks connecting the 19th Infantry Division rear echelon into the army area communications system. The "C"

line reports that circuit RFDI3426 became inoperative at 0752 and was restored at 0755 hours. The trouble corresponds to that given in the "S" line; since the circuit has been restored no assistance is required. Because the only circuit reported out has been restored, it may be assumed that channel twenty-three of system RFDI48C1 was a spare channel; otherwise an additional "C" line would have been required to show that the circuit normally routed over channel twenty-three was inoperative due to its pre-emption by the higher-priority circuit. The situation appears to be well in hand. The systems control action officer annotates the system card to show the failure of channel seventeen and the changed use of channel twenty-three of system RFDI48C1, changes the circuit card to indicate the rerouting of circuit RFDI3426, initials the report, and forwards it to the engineering branch which will use the information contained in the report for analyzing system performance and compiling reliability statistics.

Reroute action required.--The following report is received at the signal brigade systems control center:

* * *

O/RI/1ØØ8Ø7/Ø4
S/RI AD 24V1/11/OUT1ØØ758/LVB
C/12CAD 4227/Ø2/RI AD 48V1/11/V/5/OUT1ØØ758/LVR
D/1ØØ8Ø8

* * *

From the information contained in this report and the systems diagram the systems control action officer notes that circuit 12CAD4227, a direct trunk between the 2d Corps Support Brigade and 2d Corps main command post has failed

due to trouble on channel eleven of the telephone carrier system at a relay terminal. Signal center RI requests rerouting instructions. The action officer checks the system card for system RIAD48V1; all channels are in use and there are no circuits with a lower priority than circuit 12CAD4227. Referring again to the systems diagram he sees that a possibility exists of rerouting the circuit over systems RGRI48V1 and RGAD48V1. A check of the systems cards for these two systems discloses that channels forty-two through forty-eight of system RGRI48V1 and channels twenty-one through twenty-four of system RGAD48V1 are not in use; rerouting can be accomplished. The action officer prepares the following communications order, addressing it to the 704th and 705th signal battalion control centers:

```
    *    *    *
COMMUNICATIONS ORDER NR 1Ø68
REF OPORD 1Ø
1.  ACTIVATE:
    C/12CAD 4227/Ø1/RI 12C48V1/11/V/ØØØØ/5
                    Ø2/RG RI 48V1/42
                    Ø3/RG AD 48V1/21
2.  DISCONTINUE:
    C/12CAD 4227/Ø2/RI AD 48V1/11/V/ØØØØ/5
ACKNOWLEDGE
    *    *    *
```

This action is a simple one for the signal centers to execute, since it only involves a change in the patching arrangements at signal centers RI, RG, and AD, a matter of removing a patch cord from one jack and inserting it into another. Within a few minutes the following reports are received:

```
    *     *     *
REF COMMUNICATIONS ORDER NR 1Ø68
O/RI/1ØØ825/Ø5
C/12CAD 4227/Ø1/RI 12C48V1/11/V/ØØØØ/5
                Ø2/RG RI 48V1/42/IN1ØØ825
C/12CAD 4227/Ø2/RI AD 48V1/11/OUT1ØØ825/F4G
D/1ØØ827
    *     *     *

    *     *     *
REF COMMUNICATIONS ORDER NR 1Ø68
O/RG/1ØØ827/Ø3
C/12CAD 4227/Ø3/RG AD 48V1/21/IN1ØØ827
D/1ØØ829
    *     *     *
```

The action officer compares the reports with communications order 1068, annotates the system and circuit cards, initials the reports, and forwards them to the engineering branch for statistical analysis.

Updating circuit control records.--When the necessary repairs have been made to restore equipment to full operation, the signal center concerned reports the fact to the brigade systems control center. For example:

```
    *     *     *
O/RF/1ØØ921/Ø3
S/RF DI 48C1/17/IN1ØØ917/LVG
D/1ØØ923
    *     *     *
```

This report informs the systems control center that channel seventeen of system RFDI48C1, previously reported as having failed at 100752, has been restored to service.[1] Since the system card for system RFDI48C1 was changed to show channel seventeen as inoperative, the systems control action officer takes the system card and erases the entry under channel seventeen, thus indicating that the channel is

[1]See above, p. 152.

again available for use when necessary. The report is initialed and forwarded to the engineering branch for their records.

System Failure and Restoral

Failure of an entire system represents a more complicated problem than failure of a single circuit or channel, since action must be taken to restore the affected circuits, particularly those with high priorities, as soon as possible. In the case of 96-channel systems this may result in a requirement to reroute as many as 70 or 80 channels.

The impact of system failure on the army communications network can be reduced considerably by the application of two design techniques when planning the over-all army system. These are: (1) insuring that circuits established between the same locations are routed over different systems to the maximum extent possible, so that if one system fails all circuits between the same locations will not be disrupted, and (2) activating two or more radio systems operating at 50 per cent channel capacity between terminals when feasible.

The first technique serves to reduce the number of high-priority circuits which must be rerouted in the event of system failure by distributing them equally over the various systems in the army network. Common-user service can be maintained over the tandem trunks provided between signal centers for a period of time sufficient to permit

restoral of the system, although the speed of service will be reduced. Immediate rerouting action is only necessary for those circuits with priority one through three.

The second technique is made possible by the characteristics of the carrier equipment now being developed for the future field army. A medium-capacity (12/24 channel) system will be used for field army command communications, a high capacity (48/96 channel) system for the army area communications network. Both systems will combine the signal from the terminal instruments in two stages. The first stage will process twelve (or forty-eight) channel inputs into a PCM digital stream using a device known as a <u>multiplexer</u>. The second stage will convert one or two digital streams into a form suitable for radio or cable transmission by use of a <u>radio combiner</u> or a <u>cable combiner</u>. A medium capacity system may contain one or two groups of twelve channels each, a high capacity system one or two groups of forty-eight channels each.[2] A forty-eight channel system can be converted into a ninety-six channel system by inserting the output of a second forty-eight channel multiplexer into the system radio combiner. This method has the disadvantage of increasing the number of radio emitters within the army area, but this drawback is offset by the increased flexibility which the ability to reroute multichannel groups

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[2]U.S. Army Electronics Command, <u>The Army Area Communications System: Description of Subsystems; Principal Characteristics of Assemblages</u>, (Fort Monmouth, New Jersey: October 1966), pp. xv, 3-3. (File No. N-17506.48, Fort Leavenworth, Kansas Library).

instead of many separate channels gives to the system. Activation of two radio relay systems along an axis of high channel requirements increases network responsiveness by eliminating the time needed to install and activate a multi-channel radio system. The second system will be stabilized and available for expansion within a few minutes. The following examples will illustrate this procedure:

No action required.--When feasible the signal center responsible for test and alignment of the system will reroute the affected group and report the fact to the signal brigade systems control center.

*   *   *

O/AA/1Ø1ØØ2/Ø2
S/AA AD 12T1/OUT1ØØ958/LRA
S/AA AD 24T2/IN1Ø1ØØ2
D/1Ø1ØØ4

*   *   *

This message informs the control center that system AAAD12T1 failed at 0958 due to receiver trouble at the relay site, that no assistance is required, and that the signal center expects to have the system restored within one hour. The second "S" line indicates that system AAAD24T2 has been placed in service at 101002. This system was originally installed as a twelve-channel system. The action officer infers that the twelve-channel group previously routed over system AAAD12T1 has been superimposed on system AAAD12T2. He makes a penciled note on the systems card for system AAAD12T1, clips it to the card for system AAAD12T2, then initials and forwards the report to the

engineering branch. When the system is restored to service he removes the clip from the systems cards and erases his previous entry.

Circuit rerouting required.--In the event that the only system between two locations fails the systems control action officer must ascertain the cause of the trouble. When the radio equipment has failed it may be possible to reroute the affected group or groups from signal center to signal center until the terminating signal center is reached. If this course of action is not feasible he must determine those high-priority circuits which must be rerouted, ascertain the proper routes from the circuit file and the systems diagram, and issue the necessary communications orders to restore service.

System reengineering required.--System failure may occur due to causes not connected with the equipment.

* * *

O/RI/1Ø1Ø3Ø/Ø6
S/RI RH 48V2/OUT1Ø1Ø21/XJF
S/RI RH 96V1/IN1Ø1Ø26
D/1Ø1Ø36
STRONG INTERFERENCE RECEIVED ON THIS SYSTEM.
BELIEVED TO BE HARMONIC FROM TRANSMITTER OF
SYSTEM RI12048V1. REQUEST NEW FREQUENCY ASSIGN-
MENT.

* * *

In this case signal center RI has experienced a system failure due to frequency interference which it believes is caused by the transmitter of a different system. It has restored communications by superimposing the circuit group of the affected system onto system RIRH48V1. The systems control action officer records the group rerouting

and forwards the report to the engineering branch with a request for instructions. The engineering branch may be able to allocate a usable frequency from those made available to the signal brigade, or it may request an appropriate frequency from the army signal officer. When a new frequency is allocated the systems control center will prepare a communications order directing the frequency change. Upon restoral of the system the appropriate records will be posted and the engineering branch informed.

Signal Center Failure

One of the worst calamities that can happen to the army communications network is the failure of an entire signal center. This emergency is most likely to occur as the result of enemy attack or natural disaster. In either case, an on-the-spot assessment of the damage must be made to determine what assistance is required. The controlling signal battalion is the command echelon best able to investigate the disaster, determine what actions must be taken, and report the situation to the signal brigade. If the battalion is unable to provide sufficient personnel and equipment from its own resources it will request assistance from the signal brigade. When necessary, personnel and equipment may be dispatched from other signal units to restore communications, or a reserve signal center may be committed in its entirety. Unit capabilities obtained from the signal center file will be used in determining which units will provide

support. Close staff coordination between all signal brigade elements must be maintained to insure that appropriate actions are taken as quickly as possible to restore the communications network.

Unit Relocation

The relocation of a using unit requires that the gaining signal center be informed of the user's circuit requirements and its new location so that communications support can be quickly provided. Since unit displacement will normally be carried out in stages, communications must be provided to the advance party upon arrival in the signal center area of responsibility while maintaining normal communications at the old location until the user transfers his operations to his new location. Signal centers and using units must maintain close coordination with each other to insure advance knowledge of impending moves and continued communications support. Advance parties will require at least one tributary trunk connected into the supporting area signal center switchboard; specific circuit requirements for advance parties will be standardized by the army signal officer and included in the field army SOP.

Advance knowledge of unit move.--The following communications report informs the systems control center of an impending unit relocation:

* * *

O/RG/1Ø1121/Ø4
U/26D/BELVOIR ADV/EG265432/EG592236/1Ø1415
U/26D/BELVOIR/EG265432/EG592236/1Ø2Ø3Ø
D/1Ø1127

* * *

From this report and the unit file the systems control action officer determines that user 12D (the 539th Engineer Topographic Company, Corps) will establish an advance headquarters at coordinates EG592236 by 1415 hours, and that the unit itself will become operational in the same location at 2030 hours. A check of the signal situation map shows that the new location lies within the area of responsibility of signal center RH, and service can best be provided by wire lines from the signal center itself rather than from an outlying distribution center. The circuit requirements file discloses a requirement for two tributary trunks to the supporting signal center and one direct trunk to the army topographic battalion; the circuit file shows that the direct trunk is routed from signal center RL to signal center RG. A new routing is required. To minimize changes the systems control action officer decides to retain the routing RL to RG, and extend the circuit through signal center RI to RH. A circuit designator is constructed for the tributary trunk which will be furnished to the advance party. This information is combined to produce the following communications order:

* * *

COMMUNICATIONS ORDER NR 1Ø69
REFERENCE OPORD 1Ø
1. U/12D/BELVOIR ADV/EG265432/EG592236/1Ø1415
U/12D/BELVOIR/EG265432/EG592236/1Ø2Ø3Ø

2. ACTIVATE EFFECTIVE 1Ø1415 OR UPON ARRIVAL OF UNIT:
C/RH 12D5128/Ø1/RH WIRE/ØØ/V/ØØØØ/5

3. ACTIVATE EFFECTIVE 1Ø2Ø3Ø OR UPON ARRIVAL OF UNIT:
C/18Q12D3492/Ø1/RL WIRE/ØØ/V/ØØØØ/5
Ø2/RL RG 48V2/16
Ø3/RG RI 48V1/36
Ø4/RI RH 48V1/12
Ø5/RH WIRE/ØØ
C/RH 12D5129/Ø1/RH WIRE/ØØ

4. DISCONTINUE EFFECTIVE 1Ø2Ø3Ø OR UPON DEPARTURE OF UNIT:
C/12D18Q3492/Ø3/RG WIRE/ØØ/V/ØØØØ/5
C/RG 12D3921/Ø1/RG WIRE/ØØ/V/ØØØØ/5
C/RG 12D3922/Ø1/RG WIRE/ØØ/V/ØØØØ/5

ACKNOWLEDGE

* * *

When this order is received signal centers will take the necessary action to install the new circuits, reroute the direct trunk, and remove the circuits which are no longer required. A report will be furnished the systems control center when the action has been completed.

Service to transient unit.--In spite of the best efforts by all parties to coordinate unit relocations and communications support, it is quite possible that unit moves may be directed and accomplished under conditions of extreme urgency which will not permit advance notice to the supporting signal center. Announcement of new units moving into the army area may be withheld inadvertently from the signal brigade. Communications support to these units must be provided nevertheless. When transient units arrive in a signal center area of responsibility the signal center will

report the arrival and the service provided, as shown in the following report:

```
    *     *     *
O/RF/1Ø1215/Ø4
U/19P/BANTAM/EG583456/1Ø1126
C/RF 19PXXXX/Ø1/RF WIRE/ØØ/V/ØØØØ/5/IN1Ø1211
C/RF 19PXXXX/Ø1/RF WIRE/ØØ/V/ØØØØ/5/IN1Ø1211
D/1Ø1219
    *     *     *
```

This message indicates that two telephone tributary trunks have been provided to user 19P. The use of the letter "X" in the report indicates information not available to the reporting signal center. The systems control action officer must provide the omitted information to the reporting signal center. The signal information branch must be notified of the unit relocation. Systems control records must also be posted; in this case both the unit file and the circuit file must be updated. When an organization not previously listed in a route bulletin is provided communications support, the reporting signal center must include the complete unit designation in its report.

Daily Status Report

Signal centers inform the systems control center of their operational status at the close of each day. A typical daily status report appears below:

```
    *     *     *
O/RP/1Ø24ØØ/11
T/RH/TP375/TT1Ø,ØØØ
T/RK/TP786/TT14,5ØØ
T/DN/TP142/TT7,6ØØØ
E/TD-2Ø3/5/11/2
E/TD-353/5/12/3
D/11ØØ34
    *     *     *
```

This report provides the systems control center with information which it requires to recommend re-allocation of equipment between signal centers to cope with changed communications requirements. The equipment status will be entered in the signal center file; the traffic statistics will be furnished to the traffic branch for analysis and determination of circuit requirements. When changes in circuit allocation are approved the systems control center will issue the necessary communications orders to activate new circuits or deactivate those which are no longer needed.

Summary

The preceeding examples of systems control actions illustrate the application of the doctrine proposed in Chapter VI. Throughout the day, reports will be received by the systems control center, decisions made, and orders issued to the operating signal centers. The ready availability of a wide variety of information at the systems control center allows the action officers to take prompt action to realign the army communications network and insure that it is fully responsive to the needs of its users. Centralized control is maintained by keeping the systems control center fully informed of the status of the communications network. Decentralized execution is achieved by encouraging the operating elements to take all necessary actions within their capabilities as soon as possible.

CHAPTER VIII

IMPLICATIONS OF AUTOMATIC DATA PROCESSING AND AUTOMATIC SWITCHING TECHNIQUES

Two developments will have far-reaching implications with respect to the systems control function. The first of these is the use of automatic data processing equipment to receive, store, and selectively retrieve the large amount of information which the systems control center must have in order to effectively coordinate the operations of the many and varied elements of the army communications network. The second development is the use of automatic circuit switching to replace the present system of manually operated switchboards.

Automatic Data Processing

Automated systems control methods offer many advantages over manual procedures. Although manual techniques have been and can continue to be used effectively, as shown in Chapter VII, the use of automatic data processing equipment will provide greatly increased accuracy, flexibility, and responsiveness in carrying out systems control actions, many of which are repetitive and time-consuming.

Some of the numerous benefits to be gained by the use of automatic data processing equipment in systems control operations are discussed below.

Elimination of Bulky Manual Files

The use of computer equipment will permit the storage of all systems control information within memory devices, such as magnetic tape reels or magnetic core banks. The requirement for bulky manual files will cease to exist, since a read-out of the computer memory and conversion to card or page output can be accomplished at any time. Data can be entered into the master file when necessary by the use of suitable input/output devices. The circuit requirements file can be combined with the unit file and a separate circuit register will no longer be required.

Automatic Updating of Files

The systems control computer can be programmed to automatically insert the contents of communications reports in the master file, replacing obsolete information with the current status of the signal center, system, circuit, or supported unit. The date-time group of the report should be included in the file to facilitate the preparation of changes in file listings.

Preparation of File Listings and Changes

By printing the contents of the systems control files in page format, a complete listing of the systems file, circuit file, unit file, etc. can be prepared automatically in as many copies as desired for distribution to control and operating elements. Control documents such as the route bulletin can be generated by a simple program, using the data contained in the unit file. Changes to these documents can be prepared whenever necessary by directing the computer to scan the files one page at a time, note whether any date-time groups are later than the date and time of the last change, and print only those pages which contain new information.

Determination of Signal Center Locations and Missions

From the data contained in the unit file and the signal center file a computer program can be utilized to determine the units requiring signal support within a designated geographical area and the capabilities of a given signal center to provide the necessary communications services. The computer output would establish the general location for the signal center and a list of the units which it would be required to support. The signal center would retain the authority to select its exact location,

reporting the coordinates to the systems control center when determined.[1]

Computation of System and Circuit Requirements

When user and signal center locations have been determined, the unit file and traffic engineering data can be examined to determine the number of tributary and direct trunks required and the systems necessary to support these circuits. Additional traffic experience gained as a result of operations can be inserted in the computer memory, traffic engineering computations carried out, and the circuit requirements file updated automatically.

Preparation of Communications Orders

As reports are received from signal centers concerning unit relocations and system or circuit failures, the systems control computer can be programmed to provide instructions for circuit activation, discontinuance, and group or circuit routing and rerouting, based upon data contained in the unit, system, and circuit files.[2] While theoretically possible to have communications orders of this type prepared and transmitted to the operating signal centers

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[1] Theodore J. Pearson, Jr., Field Army Communications Network Planning and Control, ("Advanced Systems Planning Memorandum No. 20"; Waltham, Massachusetts: Advanced Systems Planning, Sylvania Electronics Systems, May 1966), pp. 11, 13. (File No. N-18426.38, Fort Leavenworth, Kansas Library).

[2] Ibid., pp. 25-33.

automatically, it is recommended that the computer-generated instructions be submitted to a systems control action officer for verification and validation prior to transmittal. The many intangible human factors inherent in establishing and operating a communications system seem to indicate a requirement for the exercise of human judgment in formulating orders to subordinate units.

Automatic Circuit Switching

Automatic switching of communications circuits is not new; the first commercial automatic telephone exchange was installed in 1892.[3] Within the military services the application of automatic switching techniques to military communications systems has been studied for many years. In 1958 the Chief Signal Officer of the U.S. Army was able to announce that the Signal Engineering Laboratories had underway a development program which would permit full-scale production of automatic circuit switching equipment for the army's tactical echelons by the end of 1961.[4] Due perhaps to the greatly increased costs of automatic equipment

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[3] Estill I. Green, "Telephone," <u>Encyclopedia Britannica</u> (1966), Vol. XXI, p. 901.

[4] "Inclosure to Inclosure 1, Field Army Communication Switching Concept," to Letter, Headquarters United States Continental Army Command, 18 February 1958, Subject: "Four-Wire Automatic Communications System for the Field Army (U)," p. 1. (File No. C-18378.62, Fort Leavenworth, Kansas Library). (CONFIDENTIAL--MODIFIED HANDLING AUTHORIZED.)

compared to those of manual switchboards the proposal was not adopted.[5] Developmental work has continued.

This method of switching, as presently proposed, will provide the equivalent of "direct-distance-dialing" service for almost all of the users of the army communications network. It will eliminate time-consuming manual switching and lower the number of long-distance trunks necessary by reducing the holding time consumed in placing telephone calls.[6] Transmission quality will be improved by the use of four-wire circuits, which permit circuit net loss to approach a level of zero db, regardless of the number of switching centers through which the circuit passes.[7] The improved quality of circuits and the elimination of manual switchboards will do away with the requirement for direct trunks.[8] Sole-user circuits will no longer be needed since

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[5]The cost of automatic switching equipment for the field army is estimated to be four to five times as great as the cost of manual switchboards providing the same service, depending on the extent to which automatic switching equipment is deployed within the field army structure. (U.S. Army Combat Developments Command, "Appendix V, Implications of Automatic Electronic Switching," to CD Study, "Field Army Requirements for Tactical Communications [TACOM][U]," [Fort Leavenworth, Kansas: November 1964], Vol. I, pp. V-16--V-22. [File No. C-18968.29A, Fort Leavenworth, Kansas Library]. [CONFIDENTIAL].)

[6]"Inclosure to Inclosure 1, Field Army Communications System Switching Concept," to Letter, Headquarters United States Continental Army Command, 18 February 1958, Subject: "Four-Wire Automatic Communications System for the Field Army (U)," p. 2.

[7]Inclosure 6, "Advantages and Disadvantages; 4-Wire Versus 2-Wire System," to Letter, Headquarters United States Continental Army Command, Subject: "Four-Wire Automatic Communications System for the Field Army (U),' p. 1.

[8]See above, pp. 32, 39.

[redacted]

a high-priority user will have the capability to pre-empt a circuit being used by a lower-priority call in order to reach the desired subscriber.[9]

An important effect which automatic switching will have on systems control actions is the elimination of the circuit file and the requirement to reroute circuits, since the automatic switchboard will have access to all circuits entering the signal center and no sole-user circuits will be established. Systems control activities will then be concerned primarily with system and signal center management. Traffic engineering computations will be simplified, since there will be no requirement to compute direct trunk needs.

Signal information service problems may be increased. If the automatic switching equipment is procured and issued as presently developed, it appears necessary to assign a new telephone directory number to a using unit whenever the unit changes its location.[10] Telephone directories will require continuous updating and immediate distribution to all users.

The addition of a simple memory device to an automatic switchboard would permit telephone directory information to be stored and called upon by the switchboard

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[9] U.S. Army Combat Developments Command, "Appendix V, Implications of Automatic Electronic Switching," to <u>CD Study</u>, . . . <u>TACOM</u>, Vol. I, p. V-5.

[10] <u>Ibid</u>., p. V-6.

Removed per Maj Miller, S.C. memo dtd 15 Jul 99

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itself as necessary. A using unit would be able to retain the same number no matter where located. Any subscriber placing a call would dial the desired number; the switching equipment would store the number in its memory, check its memory bank for routing instructions, complete the connection to the next signal center along the route, and transmit the stored number to the next automatic switchboard in the series. This process would continue until the desired subscriber is reached.[11]

Under these conditions the need for constant revision of the field army telephone directory will cease to exist, since the using unit will retain the same telephone number throughout its period of assignment to the field army. It will be necessary, however, to update the memory bank of all automatic switchboards as units relocate. This can be accomplished automatically if computer assistance is provided to the systems control center. As changes in unit locations are reported, the computer can determine the new signal center supporting the user, prepare routing instructions, and transmit them to the switchboards where they will replace the previous routing instructions contained in the switchboard memory.[12]

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[11]U.S. Army Combat Developments Command, "Annex B, State of the Art," to *Study, Improved Applications of Manual Signal Systems Control and Signal Information Service, for the Field Army Command and Area Communications Systems, 1965-1970 (U)*, (Coordination Draft; n.p.: June 1966), pp. B-3--B-4. (File No. N-18538.40, Fort Leavenworth, Kansas Library.) (FOR OFFICIAL USE ONLY.)

[12]*Ibid.*, p. B-5.

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Summary

Both automatic data processing systems and automatic switching techniques will have a far-reaching impact on systems control operations. Tedious and recurring operations will be carried out swiftly and automatically, bulky and awkward files will be eliminated, and up-to-date information will be stored and printed for distribution to operating and using elements whenever necessary. Many directives can be prepared with a minimum of human effort. Improved circuit quality and automatic circuit switching will do away with the requirement for control of individual circuits and the systems control center will be able to concentrate its efforts on improving the quality of communications systems and signal service to the elements of the field army. The army communications network will truly be efficient, flexible, and responsive to the needs of its users.

CHAPTER IX

SUMMARY AND CONCLUSIONS

Chapters I through III of this work outline the evolution of the field army communications system from its origin in the Civil War to the present time and discuss some of the new developments which will be incorporated into the field army network in the future. The technical requirements for adequate signal communications are explained, the needs of the future field army and its components examined, and the signal organization to satisfy these requirements outlined.

Chapters IV and V analyze the various methods of controlling the army communications network as they have been developed and applied by the several agencies and organizations which have been faced with this problem. The development of present U.S. Army doctrine for systems control as contained in Field Manual FM 11-21, Tactical Signal Communication Systems, Army, Corps, and Division, is discussed. The systems control procedures of U.S. Seventh and Eighth Armies, the improved method of manual systems control proposed by the U.S. Army Combat Developments Command in the 1966 study, Improved Applications of Manual Signal Systems Control and Signal Information Service, for the Field Army Command and Area Communications Systems,

1965-1970, and the control methods of the Defense Communications Agency are reviewed. The shortcomings of present methods of systems control are pointed out, and the requirements for an effective tactical systems control doctrine are stated.

A proposed doctrine for field army communications systems control is presented in Chapter VI and tested in Chapter VII. The responsibility for the systems control function, an organizational structure to exercise systems control, and methods to identify users, systems, and circuits are developed. Formats for systems control records, reports, and orders are prepared which are equally adaptable to manual or automated procedures. The suggested method is shown to provide an adequate system of control for the field army communications network.

Chapter VIII analyzes some of the implications which the introduction of automatic data processing systems and automatic circuit switching will have upon systems control procedures. Both techniques are seen to complement each other: automatic data processing equipment will greatly reduce the time and effort necessary to formulate and carry out systems control actions, while automatic circuit switching will eliminate one of the major tasks of the systems control element, that of individual circuit identification and control.

The proposed doctrine developed in this paper offers significant advantages over the previous methods of systems control, particularly in the areas discussed below.

Organization for Systems Control.--The concept of a separate traffic engineering branch, signal information branch, and systems control branch prepared by the U.S. Army Combat Developments Command study of 1966 is sound and is retained in this paper. The proposed doctrine clearly defines the responsibilities of the systems control branch and offers an organization for systems control that is compatible with the signal organization of the TACOM field army.

Construction of Communications Designators.--This work provides a simple and flexible system for constructing communication designators which identifies signal centers and control centers by a two-character alphabetic symbol; using headquarters, units, or agencies which terminate circuits are assigned a three-character (two digit and a letter) symbol. Blocks of designators are reserved for unit or organization headquarters, units outside the field army area, sole-user terminals, command signal centers, area signal centers, and systems control centers. The systems control element may further allocate blocks of designators as the situation requires. A sufficient number of communication designators is provided to meet all requirements.

Construction of System Designators.--System designators constructed according to the procedures outlined in this paper retain the communication designators of their terminals as the first and second components. Due to the

method of assigning communication designators, systems can readily be identified as command systems, area systems, or systems from a signal center to a high-channel user. The number of channels in the system, a symbol showing the transmission medium, and the system number complete the system designator. The type of system may be inferred from the number of channels. These systems designators require from eight to ten characters to provide all necessary information about the system. A uniform ten-character system designator is obtained in communications orders, records, and reports by inserting a space after a two-character communication designator used in constructing the system designator: for example, system RA RE 48V1.

Construction of Circuit Designators.--The proposed construction of circuit designators outlined in Chapter VI uses four to six characters to show the terminal locations of the circuit and a four-digit circuit number. Rapid identification of sole-user circuits, tributary trunks, long-distance trunks, and direct trunks between unit switchboards is possible because the system provides separate types of communication designators for signal centers, sole-user circuit terminals, and unit switchboards. Blocks of circuit numbers are set aside for assignment to teletypewriter circuits. A uniform ten-character circuit designator length for use in orders, records and reports is obtained by the same method used when constructing system designators.

The Signal Information Service.--The duties of the signal information service outlined in FM 11-21 provide adequate guidance for the operation of this service and are retained in this paper. The name "unit locator register" has been changed to "unit file." This record is maintained in card format to allow changes, insertions, and deletions to be made rapidly and efficiently. The date-time group showing when the card was prepared or changed is added to the record to provide a means of screening the file and extracting the most recent changes for dissemination to using elements.

Systems Control Records.--The graphic systems control records listed in FM 11-21 are retained in the proposed doctrine with the exception of the line route map. The detailed information provided by this record is not needed by the systems control center to carry out its mission. Information of the type normally found on a line route map which the systems control center requires for its operations may be included on the signal situation map. A description of the latter record is included in Chapter VI of this paper.

Written systems control records described in FM 11-21 have been modified to provide greater clarity, flexibility, and ease of reference. A signal center file and a circuit requirements file are added to allow the systems control center to record information about signal center capabilities and specific user requirements. Records described in

FM 11-21 as the "circuit order and record card" and the "carrier system record card" are redesignated the "circuit file" and the "system file" respectively to present a clearer picture of their function and purpose. Formats for these records are completely revised to permit their use in either manual or automated systems control procedures. The concept of circuit segments is taken from the Defense Communications Agency control procedures and applied to the circuit file for greater clarity in describing circuit routings. Additional information about the circuit, such as the type of operation, circuit priority, and security equipment used on the circuit is included in the circuit file. The concept originated by U.S. Seventh Army of providing information about the radio path in the system file is useful and provision for listing this information is made. Consideration was given to combining the system file and circuit file to produce a "circuit routing chart" of the type used by U.S. Seventh Army, but it is felt that the retention of separate files is necessary to provide ease of reference, flexibility, and full information about circuits.

Systems Control Reports and Communications Orders.--This paper provides a method for preparing concise systems control reports and orders keyed to specific records which permit rapid updating of information and swift response to communications problems. Eight types of line formats, each compatible with the record to which it refers, are used. Lines are provided which update the user, signal center,

system, and circuit files. Extracts from these files are easily converted into the proper line format to provide speed and clarity in issuing communications orders. Provision is made for narrative reports and orders whenever necessary.

The proposed method for field army communications systems control outlined in this paper provides a means for accomplishing the day-to-day control of the field army network using manual procedures that are easily converted to automatic data processing methods. It is apparent that the examples of systems control actions, the maintenance of records, and the preparation of orders shown in Chapter VII require a considerable amount of time to carry out in manual operation. Punched card equipment will relieve some of the burden on the systems control center and should be used whenever possible to reduce the time consumed in manually checking and posting records and preparing communications orders. The use of a computer when available will further relieve the systems control center from these time-consuming and repetitive tasks. No attempt has been made to write a computer program for the communications systems control procedures developed in this paper. When that effort is made at some future time it may be necessary to make minor changes in some of the proposed formats for records or reports.

The systems control doctrine presented in Chapter VI is considered the best way to identify and control communications users, signal centers, circuits and systems. The

paramount importance of these procedures lies in the fact that they provide clear and positive operating guidance for the field army systems control center and subordinate battalion control centers. Systems control actions are taken at the lowest possible level to provide flexibility in controlling the field army communications network. Centralized control is maintained by a system of simple and concise reports which gives the field army systems control center up-to-date information about the status of the field army network and its components. Application of this systems control method to the field army communications network will materially assist the signal brigade commander in the accomplishment of his mission to provide signal communications for the field army.

APPENDIX

CODES USED IN SYSTEMS CONTROL ORDERS, RECORDS, AND REPORTS

Transmission Medium Code

Symbol	Meaning
C	Spiral-four cable
H	High-frequency radio
M	Mixed system (cable system with radio relay links used to span obstacles)
T	Tropospheric scatter radio
U	Microwave (non-tactical equipment)
V	Tactical line-of-sight radio relay
W	Open wire

Type of Circuit Operation Code

Symbol	Meaning
A	60 word-per-minute teletypewriter
B	66 word-per-minute teletypewriter
C	100 word-per-minute teletypewriter
D	5 card-per-minute data transceiver
E	12 card-per-minute data transceiver
F	25 card-per-minute transceiver
G	100 card-per-minute data transceiver

Type of Circuit Operation Code

(Continued)

Symbol	Meaning
S	Speech plus half-duplex teletypewriter
V	Voice (telephone)
X	Facsimile

Reason-for-Outage Code

Position 1
Location

Ø Unidentified

A Distant Communications Center

B Local Communications Center

D Distant End

F Facilities Control (patch panel)

L Relay Terminal

P Repeater (includes radio repeaters)

R Receiver Site

S Switchboard

T Transmitter Site

U User Terminal

X Path

Position 2
Description

Ø Unidentified

Equipment Failure

A Antenna

C Cryptographic

E Terminal instrument

K Teletypewriter carrier

M Miscellaneous

R Receiver

S Signaling

T Transmitter

V Voice (telephone) carrier

Power Failure

D DC power

X AC power

Position 3
Assistance Required

Ø Unidentified

A None, restoral estimated within 1 hour

B None, restoral estimated within 2 hours

C None, restoral estimated within 3 hours

D None, restoral estimated within 4 hours

E None, restoral estimated more than 4 hours

F Frequency assignment

G None (used when report gives time IN or circuit is deactivated)

Reason-for-Outage Code

(Continued)

Position 1 Location	Position 2 Description	Position 3 Assistance Required
	Path Failure	H None, no trouble found (used when reporting restorals)
	F Frequency change	M Maintenance support (parent battalion notified)
	J Interference (man-made)	R Rerouting
	L Signal level (low, loss)	S Supply support (parent battalion notified)
	P Power limitation (for frequency used)	X Rerouting and maintenance support (parent battalion notified)
	Q Signal quality (fading, distortion)	Z Rerouting and supply support (parent battalion notified)
	W Landline	
	X Interference (natural)	
	Operations	
	2 Maintenance Procedures	
	4 Engineering/installation	
	5 Control seizure	
	6 Pre-emption	
	7 Personnel error	
	8 No contact	
	9 Cryptographic procedure	

Note:

All three positions of the code will be used even if one or more of the positions must contain a "Ø" (unidentified).

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